ROADS AND STREETS

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Establishing a State Record in Concrete Road-Building

Efficient Management Results in Unusually High Production on California State Paving Project

By R. W. EDWARDS

Junior Highway Engineer, Division of Management, U. S. Bureau of Public Roads

A MAXIMUM production of 397 batches in 8 hours on 10-ft. work, and an average daily 8-hour production of 329 batches for the entire job, is a record for state highway work in California. This record production was obtained on a project involving 11.4 miles of portland cement concrete paving on the Redwood Highway from Santa Rosa to Willowbrook, Calif.

A study of this job was made by the Division of Management of the U. S. Bureau of Public Roads, and is one of many being conducted throughout the United States for the purpose of assisting in obtaining increased production on highway construction. The study of this particular job disclosed that efficient management on the part of those conducting the work was directly responsible for the high rate of production.

Pavement Laid in Two Strips.—This project principally involved grading and macadamizing 2.4 miles of line changes, placing 26,936 cu. yd. of Class A concrete in the construction of 9 miles of pavement over an old 15-ft. concrete pavement and constructing 2.4 miles of pavement over the line changes. The specifications provided that the new pavement be laid in two 10-ft. strips, each strip having a section of 9-6-6 in. for pavement laid over the old concrete pavement, and a section of 9-7-7-9 in. for the pavement laid over the line changes.

The steel placed consisted of two ½-in. deformed steel bars, one above the other, along both the longitudinal and transverse edges of the slabs. Weakened-plane joints were inserted every 20 ft. and expansion joints were inserted every 60 ft. The transverse bars did not extend into the adjacent strip, but the longitudinal bars did extend about a foot into the adjacent slab at the weakened-plane joints. The lengths of these bars extending into the adjacent slabs were capped with tin sleeves. There were five dowel bars about 2 ft. long at each expansion joint, and these dowel bars extended into each slab and prevented vertical displacements. One end of each of these dowels was capped with a tin sleeve. Three to four men were employed to set the steel on the entire job, and on only one occasion was the paving delayed because of slow steel setting.

Cement and Steel in Place Along Subgrade. Note the Large Piles of Cement

The contract was awarded to H. H. Peterson, of San Diego, early in the fall of 1928, and was shortly afterwards assigned to E. Paul Ford, paving contractor, also of San Diego. The price bid for the concrete paving was $9.27 per cubic yard and covered all items except rough grading and macadamizing of line changes. This was equivalent to about $22,100 per mile.

The inspection work for the state of California was conducted by W. E. Rice, Resident Engineer; E. Calstad, Assistant Resident Engineer and F. W. Montell, Plant Inspector. Shirley T. Corfield, formerly assistant district engineer for the state of California, was in full charge of the job for the contractor.

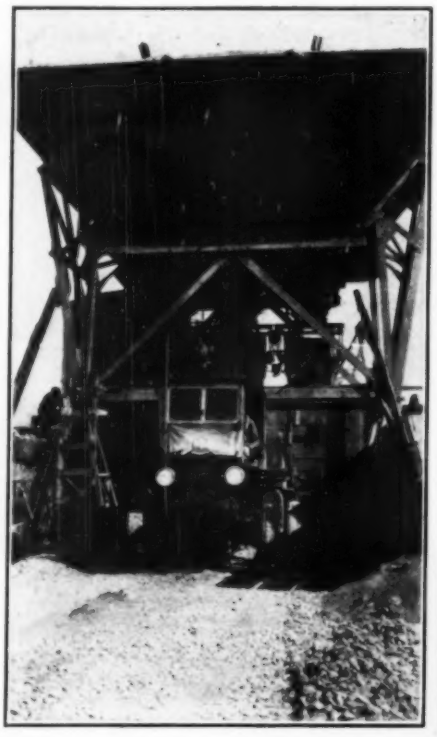
Planning, Supervision, Responsible for Progress.—Throughout the entire job the planning was kept completely separate from the execution, and few delays resulted from poor management. Furthermore, the superintendent was relieved from all such work as timekeeping, bookkeeping and the task of personally handling some particular portion of the work. He was thus able to devote his entire energy to planning and supervision.

Quite in line with the placing of the superintendent in a position to supervise properly, was the practice of employing an experienced foreman to supervise each major division of the work. These foremen were there to see that the men and equipment functioned efficiently, and that no delays occurred to curtail production. There was a man to fill each job and one man was not required to fill more than one job. Thus, through specialization on the part of the men, and through coordination on the part of the superintendent, the entire job proceeded very smoothly and at a record rate of production.

Equipment.—The major items of equipment consisted of:

1 27-E Koehring paver.
1 One-cubic-yard Koehring clam-shell crane.
1 "60" Caterpillar tractor.
1 "30" Caterpillar tractor.
1 12-ton three-wheel roller.
9 Autocar three-batch trucks.
1 150-cu.-yd. Blaw-Knox batching plant.
2 10-ft. Ord. finishing machines.
1 C. H. & E. portable water pump.
8,000 ft. steel forms.
26,500 ft. 2½-in. water pipe.

All of these pieces of equipment were in first-class condition. Paving was started on Dec. 8, 1928, and was completed on May 18, 1929. During this period of 162 days including Sundays,



Loading a 3-Batch Truck at the Batching Plant

etc., the paver operated on 82 days, the other days being lost on account of rain, wet grade, Sundays and holidays. The paving was in progress throughout the entire winter which, on account of heavy rainfall and cold weather, is the most unfavorable season of the year for paving work. This fact makes it all the more remarkable that such a high rate of production should have been obtained.

Handling of Aggregates.—Sand and rock were delivered by rail to the batching plant, which was located near the center of the job. The aggregate was unloaded from the cars by the 1 cu. yd. Koehring crane and was either stockpiled or placed in the elevated bunkers of the batcher. There were three compartments at the batcher having a total capacity of 150 cu. yd.

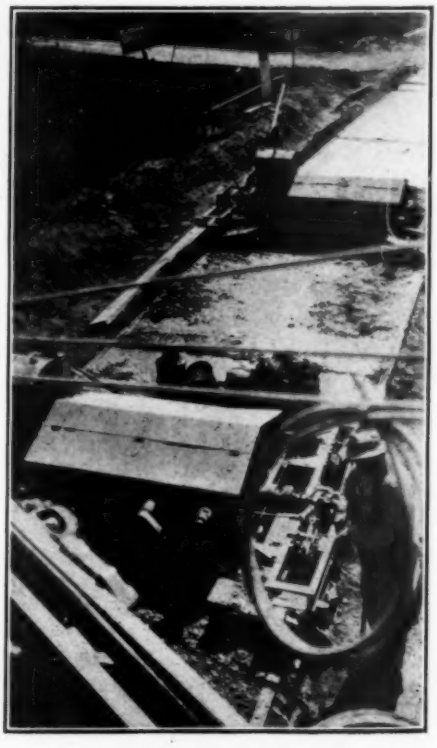
The aggregate was batched by weight and dumped into the trucks by a single batcher operator who stood in one position. The trucks were obliged to move only twice for every three batches, and this moving was done while the next batch was being weighed.

The batched materials were hauled to the paver in 3-batch Autocar trucks. The road conditions were, in general, very good and the truck speeds averaged about 28 miles per hour and at times were as high as 32 miles per hour.

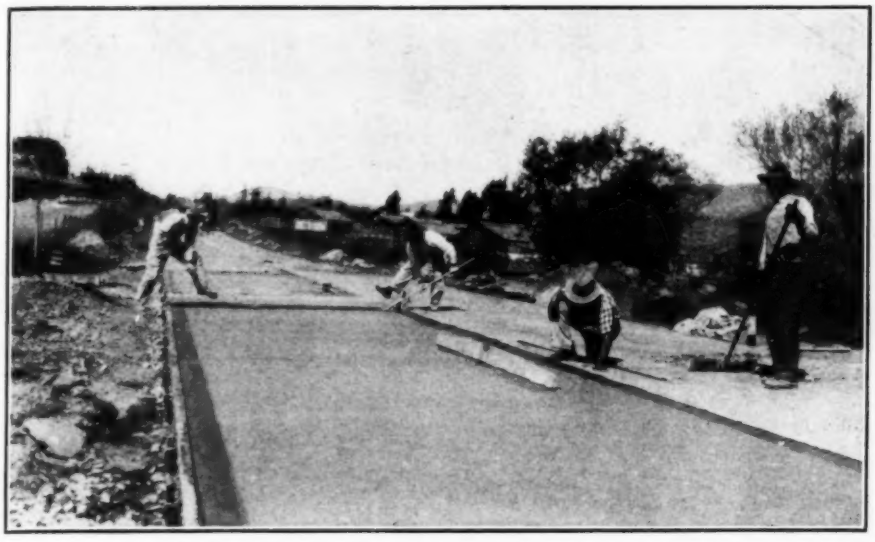
The trucks were turned about 200 ft. ahead of the paver. Very often on account of inadequate turning space, it was necessary to use a turntable.

Cement was delivered to the grade by truck and was placed in piles of about 100 sacks each on wooden racks along the grade about 100 ft. apart. As the paving proceeded, the cement was removed from these large piles by two cement handlers, and was placed in piles of 6 sacks, each 4½ ft. apart, ahead of the paver.

Mixing, Placing and Finishing.—Mixing was done in a 27-E Koehring paver. The mixing time was rigidly held at 60 seconds. This 60-second mixing time, together with 10 seconds for charging and 2 to 3 seconds for discharging, made each cycle about 72 of 73 seconds. Through consistent operation on this cycle, the maximum run of 397 batches was obtained. This rate of production does not permit of time losses and is about the best that can be obtained and still adhere to a 60-second mix. Formerly, an average



Two Ord Finishers Were Used



Final Edging

production of 300 batches per day under excellent conditions was considered as quite good. After mixing the batch was placed upon the grade and shoveled around the steel and spaded against the forms by three shovelers and two spaders.

The pavement was then smoothed out by two Ord finishing matchines working in tandem. Following these machines two men floated the slab longitudinally with a stiff back float. Following these floatmen, two men belted the slab longitudinally with a flexible wooden belt, and in the rear of these beltmen two edgers did the final edging and joint finishing. The total crew usually employed on the job, including the form setters and the curing crew, averaged about 70 men.

Street Sanitation Officials to Meet at Jacksonville, Fla.

The 10th conference of the International Association of Street Sanitation Officials will be held Oct. 14, 15 and 16 at the Hotel Mason, Jacksonville, Fla. There will be no session of the conference on Oct. 14, the day being given up to a trip to St. Augustine, golf or visiting interesting points in or around Jacksonville. At 7 p. m. there will be a meeting of the Board of Governors of the association in Parlor A, Hotel Mason. The conference will be opened officially at 9 A. M., Oct. 15.

The program of the conference follows:

TUESDAY, OCTOBER 15TH

9:00 A. M.—Opening of Conference, Roof Garden, Hotel Mason.

Address of Welcome, Dr. M. B. Herlong.

Response, Mr. Theodore Eichhorn.

President's Message.

Report of Board of Governors including Report of "Committee to Revise By-Laws as to Division of Districts." Committee consisting of following members:

Mr. Frank Raught, Chairman, Supt. Ashes and Garbage, Binghamton, N. Y.; Mr. N. M. Keller, Commissioner of Public Works, Waukegan, Ill.; Mr. H. W. Fledderman ,Supt. of Street Cleaning, Louisville, Ky.; Mr. John C. Shaw, City Engineer, Los Angeles, Cal.; Mr. E. A. Wood, Chief Street Cleaning Division, Dept. of Health, Winnipeg, Man., Can.

Report of Treasurer and Secretary.

Discussion of subjects.

12:30 P. M.—Buffet lunch, adjoining conference room, Hotel Mason.

1:30 P. M.—Continue business session, Roof Garden, Hotel Mason.

7:00 P. M.—Dinner, entertainment, Roof Garden Dining Room, Hotel Mason.

WEDNESDAY, OCTOBER 16TH

9:30 A. M.—Continue business session, Roof Garden, Hotel Mason.

1:30 P. M.—Guests of City of Jacksonville.

1—Reading of Prize Winning Papers by Jacksonville High School Pupils on "How Can Pupils of Our School Help to Keep Our City's Streets Clean."

2—How a Civic Organization Cooperates with Municipal Authorities Through High School Students in a Permanent Anti-Litter Campaign (New York City).

W. S. McGrane, Manager, Anti-Litter Bureau, The Merchants' Association of New York.

3—How Should Vehicles Pay for Street Maintenance—Vehicle Tax—Gas Tax.

Subject presented by Mr. L. W. Herzog, Commissioner of Public Works, Albany, N. Y.

Discussion led by Mr. C. A. Hillegas, Supt., Dept. of Highways and Sewers, Pittsburgh, Pa.; Mr. C. Ricksecker, Supt. of Streets, Beloit, Wis.; Mr. E. E. Anders, City Commissioner, Jacksonville, Fla.

4—Importance and Method of Care of Equipment.

Subject presented by Mr. Elmer C. Goodwin, Examining Engineer, Dept. of Street Cleaning, New York City.

Discussion led by Mr. W. J. Galligan, Asst. Supt., Bureau of Streets, Chicago, Ill.; Mr. George Ballantyne, Commissioner of Public Works, Syracuse, N. Y.; Mr. E. Paffrath, Asst. Sewer Commissioner, St. Louis, Mo.

5—Disposal of Street Dirt and Catchbasin Muck.

Subject presented by Mr. Walter A. Heimbuecher, City Engineer, University City, Mo.

Discussion led by Mr. H. D. Bradley, Deputy Street Commissioner, Toronto, Ont., Can.; Mr. Mark B. Owen, Commissioner of Public Works, Dearborn Mich.; Mr. N. W. Elsberg, City Engineer, Minneapolis, Minn.

6—Management of the Street Cleaning Personnel—How to Get Results.

Subject presented by Capt. Harrington Place, Engineer, Detroit Bureau of Governmental Research, Detroit, Mich.

Discussion led by Mr. T. J. Costigan, Supt., Street Cleaning and Collection, Washington, D. C.; Mr. P. J. Hurtgen, Director of Public Works, Kenosha, Wis.; Mr. J. W. Monarch, Street Commissioner, Boise, Idaho.

7—Municipal Asphalt Plant and Asphalt Repairs.

Subject presented by Mr. Edwin A. Miller, Superintendent of Maintenance, Department of Public Works, Rochester, N. Y. (Mr. Miller will have motion pictures in connection with his paper showing how this work is done in the city of Rochester.)

Discussion led by Mr. Roy B. Suitor, Supt. Public Works, Niagara Falls, N. Y.; Mr. I. M. Goss, Deputy Street Commissioner, South Bend, Ind.; Mr. M. J. Cronin, Commissioner of Public Works, Utica, N. Y.

8—What Does the Future Hold for Garbage Collection and Disposal.

(Frank discussion of "Report of Committee to Study Costs and Methods of Various Garbage Disposal Systems," submitted at our eighth conference.) (Secretary has extra multigraphed copies and will gladly mail copy of the report submitted by this committee at our eighth conference, on request.)

Subject presented by Mr. Carl Schneider, aide to Commissioner of Public Property, New Orleans, La.

Discussion led by Mr. J. J. Butler, Acting Supt., Bureau of Streets, Chicago, Ill.; Lieut. Bernardo Wolf, Supt. of Street Sanitation and Cleaning, Dept. of Public Works, Havana, Cuba.; Dr. M. B. Herlong, City Commissioner, Jacksonville, Fla.

9—Generation of Steam at a City Incinerator.

Subject presented by Mr. William Sydow, Supt., Division of Waste, Miami, Fla.

Discussion led by Mr. A. B. Cook, Chief Sanitary Inspector, Charlotte, N. C.; Mr. W. H. Carrigg, Supt., Garbage Department, Sioux City, Ia.; Mr. A. S. Tew, Supt., Collection and Disposal of Garbage, Mobile, Ala.

10—Dust Prevention on Unpaved Streets.

Subject presented by Mr. Matt S. Murray, Director of Public Works, Kansas City, Mo.

Discussion led by Mr. John L. Bear, City Engineer and Street Commissioner, Wabash, Ind.; Mr. J. M. Slater, Street Commissioner, St. Louis, Mo.; Mr. L. P. Booz, City Engineer, Perth Amboy, N. J.

11—Report of Committee on "How Our Association Can Cooperate with the Committee on Municipal Standards for the Development of a Measurement Standard for Street Sanitation."

Mr. Chas. A. Grossart, Chairman, Street Commissioner, Indianapolis, Ind.; Mr. L. E. Dempsey, Chief, Sanitary Department, Greensboro, N. C.; Mr. Mark B. Owen, Commissioner of Public Works, Dearborn, Mich.; Mr. William C. Tenjost, Director of Streets, Buffalo, N. Y.; Mr. Wm. G. Bank, Department of Street Cleaning, Newark, N. J.

12—Report of Committee on Simplified Uniform Cost Keeping.

Mr. G. A. Moe, Chairman, Cost Accountant, Minneapolis, Minn.; Mr. William Sydow, Supt., Division of Waste, Miami, Fla.; Mr. Roy B. Suitor, Supt. of Public Works, Niagara Falls, N. Y.; Mr. E. M. Shafter, City Engineer, Royal Oak, Mich.; Mr. Joseph J. Petranek, Commissioner of Streets and Public Improvements, Cicero, Ill.

Round Table discussion of "Problems that have been most difficult to handle in your department the past year."

Long-Distance Bus Riding Grows

A new class of long-distance travelers is being produced by America today by the facilities provided by motorcoach lines. They are people who would not otherwise stir far from home, either by train or in private automobiles, but many of them are learning to think nothing of making 1,000-mile trips without any overnight stops. Such rides are customarily broken down into shorter runs by changing vehicles or drivers at 8 to 9-hour intervals. These facts were stated by R. E. Plimpton, of Bus Transportation, at the summer meeting held at Saranac Inn by the Society of Automotive Engineers a short time ago.

This subject has some very interesting phases, as, for instance, that the number of women passengers seems to grow more rapidly than that of the men, suggesting, perhaps, a stronger brand of courage in frailer vessels, according to F. C. Horner of General Motors Corp. He also expressed the opinion that motorcoach lines have nothing to fear from competition by the rapidly developing aircraft travel. The big thing that makes for growing long-distance motorcoach trips by passengers is the low cost.

Control of Roadside Advertising and Utilities

What Is Being Done by the Various States to Regulate Outdoor Advertising

By L. I. HEWES
Deputy Chief Engineer, U. S. Bureau of Public Roads

IMPROVING traffic conditions is essentially an element of highway operation. Without creating separate operating divisions the state highway departments are necessarily developing the operating function. It is a function of increasing importance. We have, for example, seen the growth of the traffic lane idea and the traffic stripes which are purely operating devices. We have seen also the painted school zone warnings; the crossing warnings on the pavement; the refinement of super elevation, widening of curves, and increased radii, increased sight distance at curves and hilltops, flatter crowns and safer guardrail. These are all elements of operation. So are the state traffic counts. More so are the caution, direction, and warning signs recently standardized by the American Association of State Highway Officials. It would seem also that the outdoor advertising is for the highway departments an important element of highway operation.

Outdoor advertising screams loudest on the most densely traveled roads. These are the expensive roads built and maintained and largely operated by the state highway departments. These are the roads where the operating job, already difficult, is growing constantly more difficult. These are the roads where the states are straining every effort to improve the condition of travel. These are the roads where grade crossings must be eliminated with expensive structures. On such roads we know the state departments are alive to conditions of operation. There is constantly better maintenance—dust is eliminated, detours are improving, washouts are repaired with convincing dispatch, snow is removed with constantly increasing efficiency. Yet it is on these roads that rural advertising thrives and confuses the driver.

This automobile driver is distributing wealth more constantly and over a wider area than was ever dreamed of. The advertiser and the roadside merchant quickly saw the possible profit.

We are grateful for much of the roadside service. Adequate filling stations on the highway, for example. Many such stations are noteworthy examples of artistic and beautiful treatment. However, there is a descending scale of merchandising down to the hideous examples constructed of burlap and bushes, and surrounded by repulsive advertising. It is in this connection illuminating to compare the treatment of the roadside by those depending upon highway traffic patronage with the treatment by state highway and other officials.

There are noteworthy examples of roadside beautification. State Highway Departments have planted shrubs and trees. Massachusetts, Pennsylvania and California are noteworthy examples. States are also establishing beauty spots and State parks. State laws that prohibit outdoor advertising within specified distances of parks and playgrounds evidence an underlying desire to be free of the ugliness of it. But, the outdoor advertiser is aggressive and even bold. He has not hesitated to appropiate highway operating words such as STOP, DANGER, TURN, etc., for his own insistent purposes. He has used the U. S. route numbering, too. Such actions are in strange contrast to the efforts of the State highway departments to serve the owners of the highway—the motoring public now pays the bills.

42 States Have Laws on Outdoor Advertising.—An examination of the fifty typed pages of the State laws throws much light on outdoor advertising. There has been considerable progress. Forty-two states have specific statutes relating to the subject. Many of the laws are new but too many reflect conditions of the horse drawn vehicle days.

There is in the legislation much variation. No State absolutely prohibits the display of advertising within public view of the highways. There is, in many laws, an interesting note of caution. One gains the impression that advertising along the road has acquired a vested right; that although it is objectionable and even dangerous, it must be dealt with most carefully. In fact one state makes it a misdemeanor to remove advertising signs from the right of way. Recent legislation is obviously the result of motor traffic; it tends to be more stringent in the older states where traffic is densest.

Outdoor advertising may be classified for convenience as owner advertising on the premises, legal advertising by public officers, display by advertising firms, display by other advertisers (not on owner's premises). Almost universally the property owner is protected. The advertiser must, under penalty of fine, obtain the property owner's consent and usually consent from the county or town official. The owner may also almost universally display advertisements for his own product or land—only in limited instances is he restricted.

There is almost uniform recognition by the several states that the right of way of highway is forbidden ground to all except legal advertisements. Yet there are several exceptions that permit regulated display within the highways. The state highway departments have had also to remove many signs from the state highway (the elusive tin sign however sneaks over the road fence to colonize on the barbed wire property line!

New Laws Recognize Danger Points.—There is, in the newer laws, a marked evidence of the recognition of danger at curves and at railroad grade crossings. Many state laws forbid signs along the highway within a distance varying from 300 to 1,000 ft. of such crossings. Some states weaken, however, and permit legal officers to tolerate signs even within the danger limit when judged not obstructive to view. This tolerance is characteristic of the caution in many laws. Obviously a driver needs his whole attention on the road and crossing signals when approaching a grade crossing. Any advertisement may distract him. Similar provisions, with similar exceptions, apply to highway intersections and sharp highway curves. The incongruity of a warning flash displaying advertisement in the right of way is similarly obvious and yet several states, apparently to escape the cost of installation, permit such warning signals—when authorized.

It would seem that highway officials could demand that the rural right of way be entirely free of any outdoor advertising whatever. To eliminate further the advertising nuisance, wider rights of way would help. Where such wider ways cannot be secured, a "set back" line inside the property would help eliminate dangerous, distracting, and disfiguring signs. A combination of set back lines, say 100 ft. from the center line, and a restriction as to the maximum size of any outdoor advertising would markedly reduce the nuisance.

Wisconsin Set Back Provision.—Wisconsin has an original "set back" provision for highway intersection protection:

"The triangles bounded by two adjacent intersecting highways and a line drawn between the points on the center lines—one thousand feet from the intersection of their center lines, are declared prohibited ground for the erection of any danger producing

advertising signs, where such intersection is beyond the corporate limits of any city or village . . . . "

Connecticut prohibits signs within 15 ft. of the right of way line. Probably we can, as far as the rights of way themselves are concerned, hope for constantly tightening restrictions. Those states that now regulate only with fees and penalties have the power to be more and more severe and follow the lead of the others that have taken advanced positions.

When we consider the details of outdoor advertising on private property, we find a more difficult situation. We know that such advertising interferes with highway operations, that it mars the scenery, and that at times it is even dangerous. Wisconsin's "set back" law is significant. Massachusetts says: "The Division of Highways shall make rules for control of outdoor advertising on public ways or on private property within public view." Nevada regulates outdoor advertising on the public domain (as does Utah) and denies permit on any location which may measurably destroy the natural beauty of the scenery or obscure the view ahead or on curves, etc. Connecticut provides that: "The Superintendent of State Police may order the removal or change in location of any advertisement which obstructs a clear view along any highway." Advertising firms must there also take out a license and furnish a bond and no advertisement is allowed without specific permit.

There is sought a certain humor in some of the state laws. One state, as mentioned, penalizes the removal of advertising signs on the right-of-way.

Campaign of Legislation Under Way.—Obviously our highways are, with respect to outdoor advertising, in a period of transition. A campaign of legislation is under way. There is ample evidence that much is objectionable. To free the highway for operation, it will be necessary to scrutinize the owner advertiser more severely. The filling station must be sufficiently set back to allow the waiting vehicle ample room off the highway. There are also encouraging reports of proposed set back stores along California highways. There can be indirect pressure brought to bear on those who persist in defacing the highways with their owner advertisements excessive in number and in area, ugly in color, silly in phraseology, and generally objectionable.

The highways throughout the country are being equipped with standard warning and direction signs. These signs are for the most part scientifically located—they must not have a background of confusing miscellany of extraneous advertising. The condition of our highways with respect to outdoor advertising is not yet satisfactory and in many instances not safe; the best we can say is that we are progressing. It is possible that we may progress faster by organizing publicity. There are thousands of moving picture houses who might be willing to display suggestions that outdoor advertising on the highways is not wanted.

The subject lends itself to the interest of Women's Clubs throughout the country. The press is already supporting the movement for cleaner roadsides. I would leave with you the thought that there is almost enough law already scattered through the books which, if selected from the acts of the various states, would change the situation abruptly. It is probably impossible to expect a law which would involve all the effective prohibitions and limitations established by the various states, but the direction in which we may progress is nevertheless well indicated. If, for example, we would eliminate all over the fence signs within 1000 ft. of curves, highway intersections, and railroad crossings, and license, under bond and regulation, all other outdoor advertising, eliminate all advertising on public domain and public property, or that mars the scenery, then free the right of way entirely of signs, there would be little left about which to complain.

On the roadside merchant, we undoubtedly must use gentle but insistent pressure. He probably can be induced to beautify his surroundings. He must, without question, be induced to move his business sufficiently back from the traveled way so that there will be no interference whatever with the movement of traffic.

Acknowledgment.—The foregoing is an abstract of a paper presented at the Annual Meeting of the Western Association of State Highway Officials, held July 9-10 at Boise, Idaho.

Maintenance Costs

To the Editor:

The August, 1929, issue of "Roads and Streets" contained an article entitled "Highway Development and Its Problems in Indiana," by A. H. Hinkle, Superintendent of Maintenance of the Indiana State Highway Commission. In this article there appeared two tables containing data on the maintenance expenditures per mile on various types of roads on the state highway system of that state.

In connection with these tables, I am attaching hereto copies of correspondence between Mr. Hinkle and myself, in which a protest is registered in behalf of this association, concerning the apparently unfavorable maintenance costs of brick pavements as compared with concrete. You will please note in Mr. Hinkle's reply he states that "Nearly all these brick roads are more than 10 years old, although a few were built by the counties since the highway commission was created and which roads were taken into the system at a later date. Practically all of our concrete roads were built in the last 8 years." In other words, the maintenance of a rather limited mileage of brick roads more than 10 years old, constructed under county supervision, is compared to a relatively large mileage of concrete roads all constructed in the last 8 years, under state supervision. I think you will agree with me that under the circumstances the publication of such statistics is manifestly misleading and unfair to the vitrified brick type of pavement. It might be mentioned, of course, that there is no coordination of traffic, sub-soil and other conditions surrounding the two types of pavements.

The most accurate and truly comparative data regarding maintenance costs of various types of pavement, have been determined by the well known experimental road on Connecticut Avenue in Chevy Chase, Maryland, the construction of which was begun by the U. S. Bureau of Public Roads in 1911. Dr. A. F. Woods, Director of Scientific Research, U. S. Department of Agriculture, at the last annual meeting of the Highway Research Board, held in Washington, D. C., Dec. 13, 1928, made the following statement concerning this experiment: "It is believed that no other road anywhere in the world exists for which there is such a parallel record of cost and traffic covering so long a time." According to the last report on this project, contained in May, 1928, issue of "Public Roads," a journal of highway research, published by the U. S. Bureau of Public Roads, the maintenance cost for vitrified brick pavements was the lowest of any of the 17 test sections. A copy of this report is enclosed. We are also attaching a short article which gives a digest of the report.

It is a well known fact that the Department of Public Works of the city of Buffalo, N. Y., has kept a very accurate and complete record of maintenance costs of various types of street paving laid in that city, covering a period of the last 40 years. You will note from the attached article, the data of which were compiled from the 31st and last annual report of the Buffalo Department of Public Works, that the maintenance expenditure figures are most favorable to the vitrified brick type.

G. F. SCHLESINGER,
Chief Engineer and Managing Director, National Paving Brick Manufacturers' Association.

[The articles referred to in the above letter follow.—Editor.]

Brick Shows Lowest Upkeep Cost in 16-Year Government Test

After 16 years of use under actual service conditions, the U. S. Bureau of Public Roads has released maintenance figures on the upkeep of the different kinds of road materials which made up the experiment on Connecticut Avenue, Chevy Chase, Maryland, which is located a few miles from Washington, D. C. The maintenance cost of the different types of road material for the

13-year period of 1912-1924 inclusive was as follows:

	Ct. Per Sq. Yd.
Brick	2.8
Bituminous concrete	6.7
Portland cement concrete	24.4
Bituminous macadam	33.8
Surface treated water-bound macadam	89.7

At the end of 1924, according to the report, the paving east of street car tracks changed the traffic on the test road, relieving the bituminous concrete and part of the cement concrete of most of the north-bound traffic, hence costs are not truly comparable after that date. For the complete record of costs, not taking into consideration the difference in traffic until the end of 1927, the maintenance figures per square yard were: Brick, 9.2 ct.; bituminous concrete, 9.8 ct.; portland cement concrete, 34.6 ct.; bituminous macadam, 41.6 ct.; surface treated water-bound macadam, $1.21. Brick was still lowest in upkeep cost, even after the three years' additional wear. Some of the brick used in the experiment would not test as high as the standards of today require.

The concrete base underneath the brick surface was of a low cement content as compared with present-day practice, but there was no deterioration in the base due to the protection offered by the brick surface course, indicating that with a brick surface, a rich concrete base is not necessary.

In the experiments classified under bituminous macadam were included several different experiments with asphalt and coal tar. Under "Surface Treated Water-Bound Macadam" were included four different binders; two experimental areas were covered with bituminous concrete; three experiments were conducted with portland cement concrete; one experiment was carried out with vitrified brick. The figures given are average costs of maintenance for each.

Commenting on the appearance of the brick, the government report states, "That on the major portion of the brick section the surface has the same smooth, unworn appearance as originally." When the road was laid certain brick were measured so that the amount of wear could be determined. Of the brick which would meet present day specifications the test showed the average wear to be at the rate of 1 in. in 400 years.

Maintenance Figures at Buffalo

Source of information—Thirty-fifth annual report Department of Public Works, Bureau of Engineering, Buffalo, N. Y., for the fiscal year, Jan. 1-Dec. 31, 1927.

The annual reports of the Department of Public Works, Department of Engineering, Buffalo, N. Y., are very complete, and show the comparative maintenance figures on various types of street paving laid in that city.

The latest report covers the fiscal year, Jan. 1-Dec. 31, 1927.

Following are the total pavement mileage and yardage up to Jan. 1, 1928:

Type	Miles	Streets Maintained, Sq. Yd.	Streets Under Guarantee, Sq. Yd.	Total Sq. Yd.
Asphalt	403.746	3,477,503	2,969,906	6,447,409
Brick	54.672	648,788	184,537	833,325
Block stone	33.418	466,913	136,637	603,550

In recording pavement maintenance for various types of pavement, Buffalo's report differentiates between "Streets Maintained" and "Streets Repaired." In the case of "Streets Maintained" the total maintenance cost is apportioned to the total yardage of each type of pavement on which the maintenance guarantee period has expired. In the case of "Streets Repaired," the total maintenance cost is apportioned to the total yardage contained only in those streets on which the actual repairs were made. With this explanation, the report gives the following official maintenance figures for the year 1927:

Type	Sq. Yd. of Repairs	Cost per Sq. Yd. for Each Sq. Yd. Repaired	Cost per Sq. Yd. on Streets Repaired	Cost per Sq. Yd. on Streets Maintained
Asphalt	126,958	$1.9549	$0.0971	$0.0711
Block stone	1,588	1.6842	.0378	.0056
Brick	849	1.8604	.0243	.0024

The foregoing figures are on pavements out of guarantee. The following figures, taken from the report, represent pavements both in and out of guarantee:

	Sq. Yd.	
Asphalt laid up to and including 1927	9,540,518	
Asphalt taken up during city's history	2,652,648	(or 28 %)
Brick laid up to and including 1927	866,837	
Brick taken up during city's history	24,944	(or 3 %)
Block stone laid up to and including 1927	623,729	
Block stone taken up during city's history	21,808	(or 3½%)

Of repairs made between Jan. 1 and Dec. 31, 1927, on pavement out of guarantee, the following division is made:

Of the 3,447,503 sq. yd. of asphalt maintained, there were 126,958 sq. yd. of repairs—or 3.7 per cent of the total asphalt yardage.

Of the 648,788 sq. yd. of brick maintained, there were 849 sq. yd. of repairs—or ⅛ of 1 per cent of the total brick yardage.

Of the 446,913 sq. yd. of block stone maintained, there were 1,588 sq. yd. of repairs—or ⅓ of 1 per cent of the total block stone yardage.

Automobiles and World's Highway Mileage

The entire world is rapidly becoming motor-wise—following the leadership of the United States—and today there are less than a half-dozen countries in which the automobile has not found its way, says the American Motorists' Association.

"Lack of suitable roads rather than economic conditions has retarded the automobile's popularity in countries which are lagging behind," declares the association. "The United States, with 3,005,614 miles of road, has a greater world combined and this fact more than any other, perhaps, explains why there total mileage than all of the rest of the is one automobile for every five persons in this country, as compared with one automobile for every 18,744 persons in China, which has only 17,746 miles of road suitable for motoring.

"Of the total 6,582,001 miles of improved and unimproved road in the entire world, 3,574,731 miles, or 54 per cent, are found in the Western Hemisphere. Asia, with its enormous area and population, has less than a half million miles of highway, Africa only 205,902 miles, Europe 1,976,037 miles, and Oceania, including Australia and the Pacific Islands, 406,874 miles. Europe, however, has nearly four times more improved mileage than the United States.

"In the Western Hemisphere there is one mile of road to every 4.4 square miles of area, seven automobiles for every mile of road, and 9.2 persons for every automobile in use. In Europe there is one mile of highway for every 5.2 square miles of area, 20.7 automobiles for every mile of road, and 100.4 persons for every automobile in use.

"Africa has one mile of highway for every 48.1 square miles of its area, 1.35 automobiles for every mile of highway, and 493.2 persons for every automobile in use. Australia and the Pacific Islands have a mile of road for every 8.1 square miles of the combined area, 1.76 automobiles for every mile of road and 12.8 persons for every automobile in use. Asia, however, has only one mile for every 248.8 square miles of its extensive area, less than one car for every mile of highway and 2,642.3 persons for every car in use.

"Abyssinia and French Somaliland are the only countries or provinces without roads in the entire world. Macao, an Asiatic country, has only 9 miles of highway and Spanish Guianea, in Africa, has 9 miles. Only three or four of the very small political subdivisions of Africa and several island provinces have not yet been invaded by the automobile. In all of these instances the topography of the land is badly adapted to motor transportation.

Fine Aggregates in Bituminous Mixtures

Voids—Workability and Compressibility—Stability—Moisture Absorption—Durability

By HUGH W. SKIDMORE
President, Chicago Paving Laboratory, Chicago, Ill.

THE subject of fine aggregate in bituminous mixtures immediately divides itself into two distinct sections requiring somewhat different treatment in discussion:

1. Fine aggregate, exclusive of filler; and
2. Filler.

Although the primary function of both is the reduction of voids both as to amount and size, the filler performs a special function in stabilizing the mixture. In fine mixtures such as sheet asphalt, the mineral aggregate is 100 per cent fine, but in bituminous concrete it may vary from only 10 or 15 per cent in very coarse, open mixtures, to 80 per cent or more in stone-filled sheet mixtures.

Obviously, then, its function with respect to reducing voids in coarse aggregate may be gradually modified until a small amount of coarse aggregate actually reduces the voids in the fine aggregate as in the case of stone-filled mixtures. Fortunately, a general conception of sheet asphalt, with respect to sand-filler combinations, gives also similar knowledge of the combined aggregate in even a coarse aggregate type of mixture, the same laws relative to voids, bitumen content and stabilizing value of sand and filler holding true for all, with special consideration being given to coarse aggregate properties such as hardness, toughness, etc.

When one bears in mind the fact that fine aggregate in addition to filling voids in coarse aggregate and greatly increasing its impermeability, also reduces harshness of the mixture and renders it more workable and compressible, he is prepared to study the behavior of fine aggregate, that is, the sand and filler, as a separate entity, realizing that it behaves in like manner when combined with coarse aggregate. In other words, when considering filled mixtures, we simply move up or down the scale as the maximum size of aggregate decreases or increases.

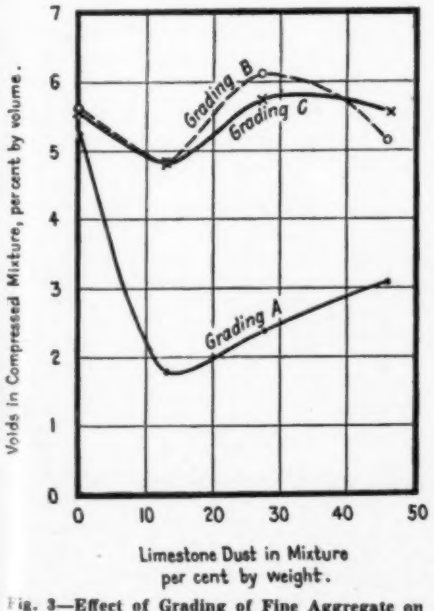


Fig. 3—Effect of Grading of Fine Aggregate on Compressibility

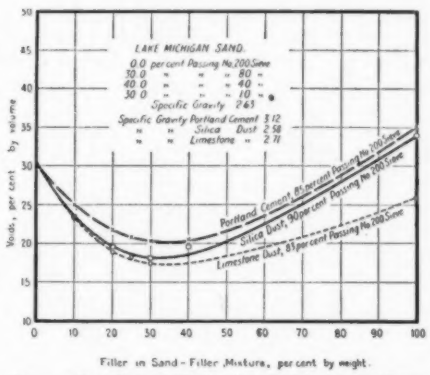

LAKE MICHIGAN SAND.
0.0 per cent Passing No.200 Sieve
10.0 " " " 80 "
40.0 " " " 40 "
50.0 " " " 10 "
Specific Gravity 2.65
Specific Gravity Portland Cement 3.12
" " Silica Dust 2.68
" " Limestone " 2.71
Portland Cement, 81 per cent Passing No.200 Sieve
Silica Dust, 90 per cent Passing No.200 Sieve
Limestone Dust, 81 per cent Passing No.200 Sieve
Voids, per cent by volume
Filler in Sand-Filler Mixture, per cent by weight.

Fig. 1—Results of Tests for Voids in a Given Sand with Special Types of Filler

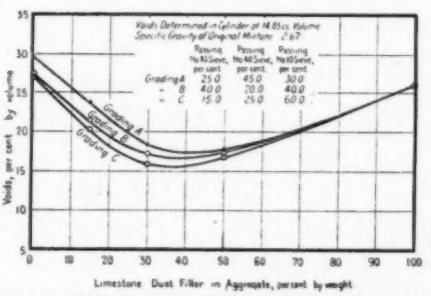

Voids Determined in Cylinder of 14.85 cc Volume
Specific Gravity of Original Mixture 2.67
Grading A
Grading B
Grading C
Voids, per cent by volume
Limestone Dust Filler in Aggregate, per cent by weight

Fig. 2—Difference in Voids with Variations in Grading of a Given Sand in Combination with a Given Filler

Voids.—As the result of the work of a number of investigators, the determination of aggregate voids in comparatively heavy metal containers capable of receiving repeated, heavy blows and employing dry aggregate packed to refusal, has proved to be the most reliable method. This method gives lower voids than any other method so far investigated and gives results that are entirely reliable for use in designing mixtures, the results checking field practice.

Typical results on sand-filler combinations are shown in Fig. 1. Curves of this sort serve as the basis of mixture design. It will be seen that the three fillers give different results with a given sand, and this is typical. Because of this difference in fillers, it is essential to examine each one proposed for use.

It is obvious that the filler producing the lowest voids, other things being equal, will be the most economical from the standpoint of asphalt required, and unless the difference in cost of filler offsets this, void-reducing ability may govern in the purchase. This holds true unless there is considerable difference in workability and compressibility of mixtures employing the various fillers examined.

Fine aggregates exclusive of filler also vary greatly with respect to voids and may influence workability and compressibility very measurably. Manipulation of proportions of a composite sand may have great influence upon mixture economy and quality of finished work by reducing voids, rendering mixtures more workable, etc. The first step in selection of aggregate then becomes a study of fine aggregate available exclusive of fillers, then in combination with available fillers. Selection results from a consideration of:

1. Voids;
2. Workability and compressibility of mixtures under field conditions, which can be simulated in the laboratory;
3. Stability of resulting mixture;
4. Moisture absorption; and
5. Durability of aggregate, that is, resistance to abrasion, crushing, etc.,

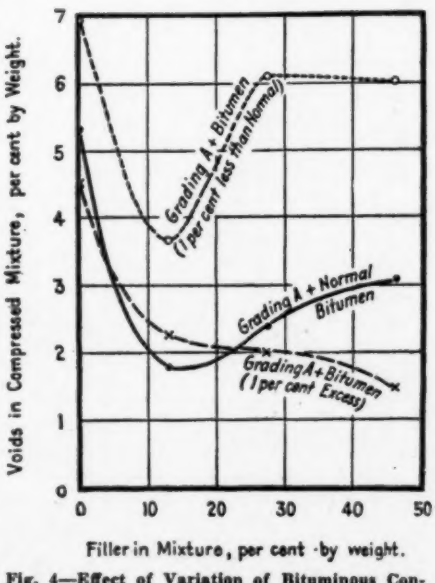

Grading A + Bitumen
(1 per cent less than Normal)
Grading A + Normal
Bitumen
Grading A + Bitumen
(1 per cent Excess)
Voids in Compressed Mixture, per cent by Weight.
Filler in Mixture, per cent by weight.

Fig. 4—Effect of Variation of Bituminous Content on Compressibility of Bituminous Mixtures

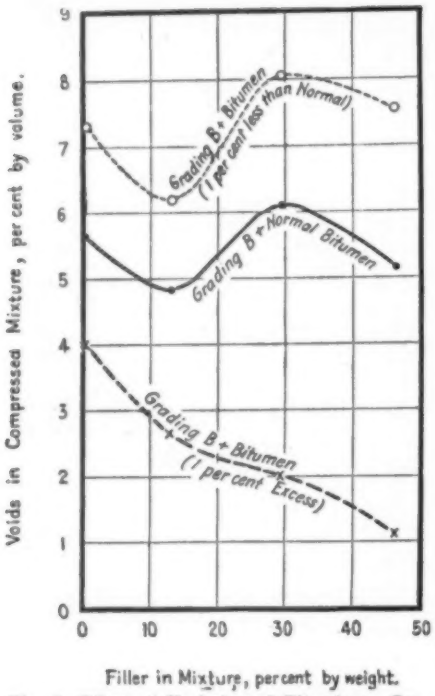

Voids in Compressed Mixture, per cent by volume.
Grading B + Bitumen (1 per cent less than Normal)
Grading B + Normal Bitumen
Grading B + Bitumen (1 per cent Excess)
Filler in Mixture, per cent by weight.

Fig. 5—Effect of Variation of Bituminous Content on Compressibility of Bituminous Mixtures (Inferior Sand Grading)

which is worthy of consideration but is ordinarily of secondary importance, since quite porous, soft aggregates have proved their merit in bituminous mixtures. They are usually inferior only in the case of large sizes in concretes or macadam. In some respects, soft, porous fine aggregates are substantially superior to sharp, hard ones.

Figure 2 illustrates the difference in voids with variation in grading of a given sand in combination with a given filler. This figure will also be used in the discussion of compressibility and stability.

Workability. — Workability cannot readily be measured mechanically in the laboratory and is really very largely dependent upon observation during mixing and placing operations. The temperature of the mixture and the conditions of the atmosphere affect workability. Certain aggregates produce poor workability due to the grading, surface texture, angularity, etc., and certain fillers are either beneficial or otherwise. Compressibility is related to workability but not necessarily in a direct ratio. For example, one filler may increase workability and decrease compressibility as compared with another. But poor compression follows poor workability purely as a mechanical function. The experienced laboratory technician can detect good or bad mixtures with respect to workability during their preparation in the laboratory.

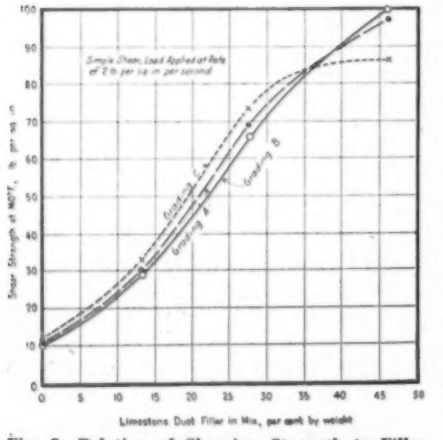


Fig. 7—Relation of Shearing Strength to Filler Content of Mixtures of Several Gradings with Asphalt Cement Just Filling Voids in Aggregate

Grades Are Those Shown in Fig. 2. Asphalt Cement: Mexican Asphalt of 40 Penetration. See Table I

Compressibility. — Compressibility is one of the most important properties of any bituminous mixture, as it affects the durability of the pavement through denseness (resistance to moisture), ravelling, cracking and surface roughness (such as choppy waves). If a mixture cannot ordinarily be compressed to within approximately 95 per cent of its theoretical maximum density, it may prove to be unsatisfactory, and

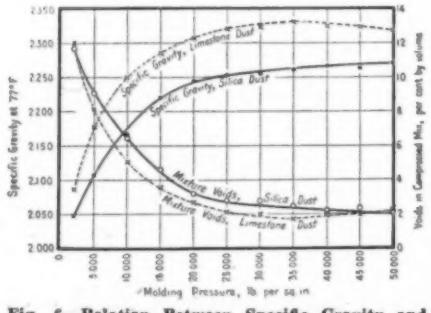

Specific Gravity at 77°F
Voids in Compressed Mix, per cent by volume
Specific Gravity, Limestone Dust
Specific Gravity, Silica Dust
Molding Voids, Silica Dust
Molding Voids, Limestone Dust
Molding Pressure, lb per sq in

Fig. 6—Relation Between Specific Gravity and Compressibility of Bituminous Mixtures to Intensity of Molding Pressure

if the compression falls much below this, early failure is inevitable.

The effect of grading of fine aggregate upon compressibility is shown in Fig. 3. Mixtures were made up with various amounts of a given filler and the fine aggregate gradings of Fig. 2, using the same asphalt for all in an amount required to fill voids, with the result that grading A produced excellent compressibility while the others were correspondingly poor. It is also obvious that the amount of filler has an effect upon the compressibility of the mixture, in this case reaching a maximum at about 15 per cent and gradually increasing mixture voids as the amount of filler increases. It is significant that a decrease in amount of filler reduces compressibility much more rapidly than does an increase. While other aggregates will not agree exactly with this case it is typical of such a study and clearly indicates the importance of this property.

Compressibility is also affected by the amount of bitumen employed in the mixture as is shown in Fig. 4. Less bitumen than is required to fill voids reduces compressibility and except in a few cases of peculiarities of certain fillers or fine aggregates, an excess of bitumen offers no advantage except for high filler content well beyond the amount ordinarily used in paving practice. Figure 5 illustrates this point in the case of an inferior sand grading, Grading B of Fig. 2. Similar data for Grading C duplicates Grading B very closely.

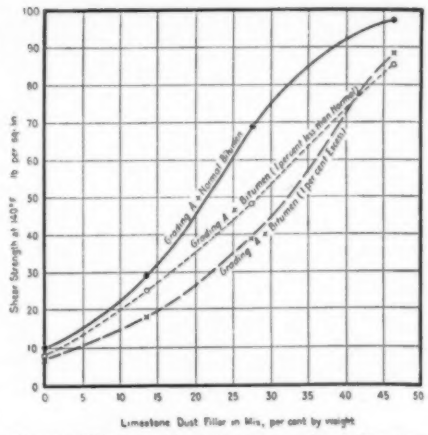

Shear Strength at 140°F, lb per sq in
Grading A + Normal Bitumen
Grading A + Bitumen (1 percent less than Normal)
Grading A + Bitumen (1 per cent Excess)
Limestone Dust Filler in Mix, per cent by weight

Fig. 8—Effect on Shearing Strength of Varying Amount of Asphalt Content

Grading Shown Is Grading A of Fig. 2. See Table II

The relation between specific gravity, compressibility (mixture voids) and loads applied (vertical pressure) in forming test cylinders 1 in. in diameter is shown in Fig. 6, the materials being taken from supplies in use. It will be noted that there is practically no gain beyond 25,000 lb. per sq. in. Pressure of this type of 5,000 lb. per sq. in. is equivalent to rolling with 10 to 12-ton 3-wheeled rollers in the field.

Stability (Shear Strength at 140° F.). —A detailed description of a test for stability is given in an earlier article by the author.[1]

Stability is an important property of mixtures. Tests are made at 140° F. as this represents about the maximum pavement temperature during hot weather when mixtures are most apt to distort. It has been found to be a very valuable test for both laboratory in-

[1]H. W. Skidmore, *Roads and Streets*, January, 1929.

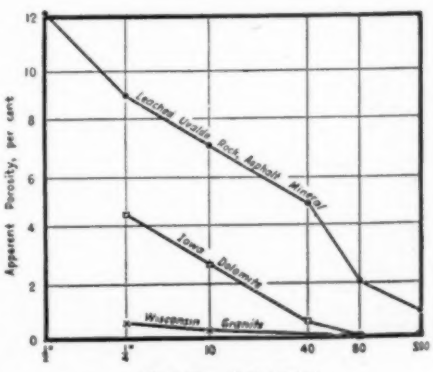


Fig. 9—Typical Porosity Curves for Three Classes of Material

Table I—Results of Stability Tests on Mixtures of Several Gradings with Asphalt Cement Just Filling Voids in Aggregates

Data Plotted in Fig. 7

Voids in Aggregate, per cent	Bitumen to Fill Voids, per cent[a]	Theoretical Specific Gravity	Specific Gravity of Cylinder, 77° F.[b]			Shearing Strength at 140° F.,[b] lb. per sq. in.			Voids in Compressed Mix, per cent
			Minimum	Maximum	Average	Minimum	Maximum	Average	
Grading A									
29.7	14.3	2.190	2.070	2.080	2.075	8.9	9.9	9.5	5.25
23.9	11.0	2.288	2.241	2.255	2.247	27.7	30.5	29.2	1.79
18.5	8.2	2.380	2.320	2.329	2.323	67.2	72.2	69.8	2.39
17.9	7.9	2.396	2.317	2.327	2.322	92.3	110.3	97.4	3.09
Grading B									
27.5	13.0	2.226	2.090	2.111	2.101	8.9	10.1	9.7	5.62
21.5	9.7	2.327	2.211	2.219	2.215	27.3	30.3	28.7	4.82
17.2	7.5	2.402	2.248	2.261	2.255	58.9	73.4	65.7	6.12
17.4	7.6	2.405	2.273	2.290	2.281	95.5	106.0	100.6	5.16
Grading C									
27.1	12.8	2.231	2.069	2.119	2.102	11.2	12.1	11.7	5.58
20.3	9.1	2.346	2.226	2.237	2.233	30.3	36.6	32.9	4.82
16.0	6.9	2.420	2.270	2.300	2.280	70.0	80.2	73.4	5.78
16.9	7.4	2.413	2.276	2.284	2.279	77.9	103.3	86.6	5.55

[a] Specific gravity of bitumen 1.053.
[b] Two-inch cylinders molded at 350° F. under pressure of 5000 lb. per sq. in.

vestigation and control during construction. Stability is materially affected by such factors as:

1. Variations in grading of aggregate;
2. Shape, surface texture, porosity and rugosity of aggregate;
3. Filler fineness, shape of grains, etc.;
4. Nature and consistency of the bitumen;
5. Denseness of mixture;
6. Uniformity of mixture which is directly associated with manufacture;
7. Poor workmanship in construction; and
8. Temperature of the test.

Figure 7 and Table I show the stabilities of the mixtures made from aggregates of the gradings shown in Fig. 2. Here we find nicely illustrated the fact that stability bears a rather constant relation to amount of filler in the aggregate. Figure 8 and Table II clearly show the falling off in stability when the bitumen is substantially either more or less than the amount required to fill aggregate voids.

Absorption.—Absorption, while an important property of the mixture, is not necessarily determined in control work, since mixture voids serve as an accurate index of mixture absorption. It is quite essential in original investigation of materials. Some materials, such as certain clays, might be proposed for use as fillers and might show good stability and low mixture voids, but when mixtures containing them are subjected to moisture, they disintegrate rapidly, due to emulsification of the bitumen.

Arbitrary tests on fillers for emulsifying properties have been proposed by some as a quality test. They are apt to be very misleading unless performed by one thoroughly familiar with the subject of emulsions. Such tests are not only unreliable but unnecessary, since the absorption test is a certain detector of unsuitable materials in this respect.

Table III gives the results of a study of five distinctly different fine aggregates in combination with a given amount of two fillers widely used in practice, as follows:

Fine Aggregates

1. Crushed, red Wisconsin granite, a very hard, tough non-porous material;
2. Ottawa sand, very sharp and non-porous;
3. Lake Michigan sand, widely used in asphalt paving work;
4. Crushed limestone from Wise County, Tex. A soft material of moderate porosity; and
5. Crushed limestone, from the region of limerock asphalt, Uvalde County, Tex., from which the bitumen has supposedly leached out by exposure. Very porous and rather soft, though not as easily crushed as No. 4.

Fillers

1. Limestone dust of excellent quality produced by the Black-White Lime Co. of Quincy, Ill. (83 per cent passing a No. 200 sieve); and
2. Silica dust of excellent quality produced by The Toledo Vitrified Brick Co., Toledo, Ohio (90 per cent passing a No. 200 sieve).

Bitumen

Mexican asphalt produced by the Standard Oil Co. of New Jersey, of 61 penetration at 77° F.

All mixtures were prepared and tested in strict accordance with standardized laboratory procedure as described in detail in the paper previously cited.[1] Apparent porosity was determined by calculation from the displacement in kerosine or any fairly stable liquid which wets the surface freely, in a Le Chatelier specific gravity bottle at 77° F. The sample was separated into various sizes (passing No. 200, No. 80, No. 40, No. 10, etc., sieves) and the readings taken for each size independently. Specific gravity of the whole was taken as that of the portion passing the No. 200 or No. 80 sieve (these are usually the same). Particles No. 80-size and finer show very low porosity even in the case of very porous materials. Typical porosity curves on three classes of material are shown in Fig. 9; a very porous material with pores extending into very small sizes; a moderately porous dolomite with pores confined to larger sizes; and a non-porous granite.

The table includes data on voids, compressibility or shear strength, and absorption.[2]

[1] H. W. Skidmore, *Roads and Streets*, January, 1929.

[2] Since this paper was prepared, a study has been made of mixtures employing the same silica dust used in these experimental mixtures, in comparison with a limestone dust widely used in the same district as the silica. These two fillers were combined with a lake sand of excellent quality, common to the territory, in different proportions and the mixtures were then modified to make proper allowance for the difference in volume-weight of the two fillers.

The results obtained plainly show that the two fillers give equivalent mixtures with respect to vital characteristics such as stability and absorption, with the silica dust only slightly less compressible and at the same time productive of slightly greater yield. Thus it is seen that what may hold for one combination of aggregates may not hold for another.

Table II—Results of Stability Tests on Mixtures of Fine Aggregate with Varying Amounts of Asphalt Cement

Data Plotted in Fig. 8

Voids in Aggregate, per cent	Bitumen, per cent		Theoretical Specific Gravity	Specific Gravity of Cylinder, 77° F.[a]			Shearing Strength at 140° F.,[a] lb. per sq. in.			Voids in Compressed Mix, per cent
	Required to Fill Voids	Used		Minimum	Maximum	Average	Minimum	Maximum	Average	
Normal Asphalt Content										
29.7	14.3	14.3	2.190	2.070	2.080	2.075	8.9	9.9	9.5	5.25
23.9	11.0	11.0	2.288	2.241	2.255	2.247	27.7	30.5	29.2	1.79
18.5	8.2	8.2	2.380	2.320	2.329	2.323	67.2	72.2	69.8	2.39
17.9	7.9	7.9	2.396	2.317	2.327	2.322	92.3	110.3	97.4	2.27
Asphalt 1 Per Cent in Excess										
29.7	14.3	15.3	2.187	2.075	2.091	2.088	5.1	8.6	7.1	4.52
23.9	11.0	12.0	2.263	2.195	2.218	2.212	15.3	19.7	18.3	2.25
18.5	8.2	9.2	2.353	2.282	2.314	2.306	35.7	42.0	39.4	2.00
17.9	7.9	8.9	2.341	2.297	2.310	2.306	81.1	91.9	88.6	1.49
Asphalt 1 Per Cent Less than Normal										
29.7	14.3	13.3	2.246	2.084	2.091	2.088	6.4	8.9	7.9	6.95
23.9	11.0	10.0	2.317	2.223	2.243	2.232	21.7	29.9	25.4	3.67
18.5	8.2	7.2	2.399	2.244	2.261	2.253	43.9	51.6	48.2	6.10
17.9	7.9	6.9	2.428	2.278	2.293	2.282	81.1	89.0	85.5	6.02

[a] Two-inch cylinders molded at 350° F. under pressure of 5000 lb. per sq. in.

Voids: The silica dust produced lower voids than the limestone dust in the case of granite, Lake Michigan sand and Uvalde County limestone, with the limestone dust superior in the other two cases.

Compressibility: The limestone dust produced much more compressibile mixtures in all cases. An increase in bitumen in the case of silica dust increased compressibility for all aggregates but also caused a falling off in stability of from 8 to 12 lb. per sq. in.

tice by the great durability and stability of limerock asphalt pavements, such as those produced from Texas and Alabama deposits. These mixtures, properly compounded, even when laid very thin (¼ to ½ in. thick) possess remarkable stability and wearing qualities. By the same token, materials such as granite have proved themselves excellent aggregates in bituminous mixtures. Water-worn sands, on the other hand, are the most abundant and generally available fine aggregate materi-

Table III—Results of Tests on Combinations of Fine Aggregate and Filler

Fine Aggregate	Filler	Specific Gravity of Aggregates	Voids in Aggregate, per cent	Bitumen Required, per cent	Specific Gravity of Mixture		Voids in Compressed Mixture, per cent	Apparent Porosity of Fine Aggregate, per cent	Composition of Mixture per cent by weight					Shearing Strength at 140° F., lb. per sq. in.	Absorption per cent		
					Theoretical Maximum	Compressed Cylinders			Bitumen	Filler	80	40	10		24 hr.	48 hr.	96 hr.
Granite	Limestone	2 636	22.2	10.22	2.284	2.207	2.7	0.16	10.22	17.96	17.96	32.32	21.54	52.3	0.5	0.8	0.9
Ottawa Sand	Limestone	2.659	16.6	7.30	2.392	2.165	9.5	....	7.3	18.54	18.54	33.37	22.25	26.4	2.6	2.7	3.1
Lake Michigan Sand	Limestone	2 681	22.2	10 07	2.319	2 226	2.8	....	10.07	18.0	18.0	32.36	21.57	20.0	0.4	0.5	0.7
Wise County, Tex., Limestone	Limestone	2 688	17 5	7 67	2.402	2.310	3.8	1.5	7.67	18.47	18 47	33.23	22.16	119.2	0 3	0.4	0.7
Uvalde County, Tex., Leached Rock-Asphalt	Limestone	2.681	23.8	10.92	2.293	2.222	3.1	5.0	10.92	17.82	17.82	32 07	21.37	107.0	0.4	0.6	0 8
Granite	Silica	2.612	18.6	8.43	2.322	2.042	12 1	....	8.43	18.31	18.31	32.97	21.98	44.4	1.6	2.3	3.6
Granite	Silica	2 612	18.6	8.43	2.297	2.082	9.4	....	9 43	18 11	18.11	32.61	21.74	32.1	1.3	1.9	2 7
Ottawa Sand	Silica	2.634	16.9	7.51	2.367	2.103	11 1	....	7.51	18.5	18.5	33.3	22.19	26 0	1 2	1.3	2 1
Ottawa Sand	Silica	2.634	16.9	7 51	2.295	2.145	6.5	....	8.51	18.3	18.3	32.94	21.98	17.0	0.7	0 9	1 (
Lake Michigan Sand	Silica	2 656	19.3	8 65	2.346	2.116	9.7	....	8.65	18.27	18.27	32.89	21.92	39.5	1 0	1 3	2 (
Lake Michigan Sand	Silica	2.656	19.3	8 65	2.316	2.153	7.0	....	9.65	18.07	18.07	32.53	21.68	31.3	0.5	0 6	1 6
Wise County, Tex., Limestone	Silica	2.663	19 6	8.78	2.347	2.192	6.6	....	8.78	18.24	18.24	32.85	21.89	65.9	0.7	0.9	1 5
Wise County, Tex., Limestone	Silica	2.663	19 6	8.78	2.331	2.243	3.8	....	9.78	18.04	18 04	32.48	21.66	57.0	0.3	0.5	0 7
Uvalde County, Tex., Leached Rock-Asphalt	Silica	2 656	23.1	10.65	2.285	2.100	8.1	....	10.65	17 87	17.87	32.17	21 44	72.4	1.2	1.5	2 1
Uvalde County, Tex., Leached Rock-Asphalt	Silica	2 656	23 1	10 65	2 276	2.174	4 5	..	11 65	17.67	17.67	31.81	21.20	64 4	0 5	0.7	0 9

Limestone dust produced low mixture voids in all cases except Ottawa sand. The extreme sharpness of sand grains in this case is thought to be the reason for poor compressibility.

Stability (Shear Strength): It is very obvious that increasing bitumen beyond the amount required to fill voids reduced stability. Silica dust mixtures gave lower stability for all aggregates except Lake Michigan sand.

There is a vast difference in stability value of different aggregates. Porous aggregates, even the very soft limestone, show much higher values than the sands, with crushed granite intermediate. The rugosity of the granite, although the granite was of non-porous structure, has a decided effect upon stability due to offering more points of contact. The water-worn lake sand naturally is low in value, with only the Ottawa sand-silica combination showing lower strength.

The unusually high stability of the Texas limestone is borne out in practice by the great durability and stability of limerock asphalt pavements, such as those produced from Texas and Alabama deposits. These mixtures, properly compounded, even when laid very thin (¼ to ½ in. thick) possess remarkable stability and wearing qualities. By the same token, materials such as granite have proved themselves excellent aggregates in bituminous mixtures. Water-worn sands, on the other hand, are the most abundant and generally available fine aggregate materials in use, and they are capable of producing good results but, as is quite clear, they require more careful investigation and manipulation than either of the other two classes mentioned in order to insure the best results. Bituminous mixtures of both the sheet and concrete types showing shearing strength of 50 lb. per sq. in. and better, have repeatedly demonstrated their ability to resist distortion under most severe traffic conditions, while otherwise excellent mixtures of 25 to 45 lb. per sq. in. shearing strength have developed ruts and waves (shoves) under the same traffic. Thus it will be seen that mixtures must be designed to withstand traffic of a specific nature and volume; and hence the extreme importance of stability.

Absorption: Absorption is obviously a function of denseness of mixture and consequently is directly related to compressibility of the mixture.

In general, the limestone mixtures are superior to those employing silica, the Ottawa sand fine aggregate being the only exception. This is conclusive proof that the nature of the sand is the controlling factor in that particular case.

By increasing the amount of bitumen in the silica mixtures, absorption was materially decreased, along with decreased mixture voids and stability.

This test for absorption shows the importance of good compressibility.

Special Fillers.—Fillers most commonly used in bituminous mixtures include such materials as limestone dust, silica dust, portland cement, both raw and finished, slate dust, etc. Of these, limestone dust is the most extensively used as it is more widely distributed than any of the others. Materials such as asbestos dust and diatomaceous earth (of the Celite type) have also been used with much success. As an example of remarkable properties that may reside in filler materials, the case of diatomaceous silica is cited, since it has been extensively investigated and has demonstrated its merit as a filler.

The material is extremely fine and weighs only about 20 lb. per cu. ft. as against 75 to 95 lb. per cu. ft for the average filler material. A considerable percentage of its particles are spicules and although its void-reducing properties are slight, compared with limestone or silica dust, it imparts remarkable stability to the mixture, and when employed in judicious amounts, increases both compressibility and workability. In one case of its use, it was found that 5 per cent of Celite and 15 per cent of limestone dust produced 2.5 times the stability as in the case of the same aggregate with 25 per cent of the limestone dust. The remarkable stabilizing value of this particular material resides in the nature and shape of its particles.

From the foregoing it will be evident that the field of fine aggregates for use in bituminous paving mixtures is by no means a closed one, either with respect to fillers or sands, natural or manufactured. The last word on suitable aggregates has not yet been written. By the same token, none of the materials should be used blindly but only with a complete understanding of its properties.

Acknowledgment.—The foregoing is a paper presented for a "Symposium on Mineral Aggregates" at the 32nd annual meeting of the American Society for Testing Materials, held June 24 to 28 at Atlantic City, N. J.

Gasoline Tax in Australia.—The Federal government refused the application of the state governments for an additional petrol tax of 4d a gallon to be returned to them. The premiers of Victoria and South Australia have announced that they will endeavor to impose the tax in spite of this refusal. It is expected that the South Australian premier will make the first attempt at an imposition of the tax.

The Nature of Scientific Explanation

Boundaries Between All Sciences Merely Artificial

By HALBERT P. GILLETTE

THERE are two excellent evidences of a well trained scientific mind: (1) habitual carefulness in defining words and terms and (2) habitual searching for explanations.

The first of these characteristics indicates carefulness in the use of that engine of thought called language. The second shows reasoning power, for until a man has become a personified question mark he is apt to be little more than a rubber stamp, a "me too" person who sets his seal of approval upon what someone else recommends.

Perhaps both of these qualifications, namely the ability to define and the ability to inquire, may be illustrated by considering the meaning of the word "explain."

Almost every modern book on logic discusses both the art of defining and the meaning of explanation; but unfortunately logic has fallen into such disrepute that relatively few engineering or scientific schools make the study of it compulsory.

If you will write your definition of the meaning of the word "explain," and later compare it with the meaning that is assigned to it below, you will probably realize that it is no easy matter to define even so common a term as "explain." If you can not define "explain" perhaps you may be lacking in ability to explain, and you may even lack ability always to know when a thing has been explained.

Lest it be assumed that weakness in language is no evidence of weakness in reasoning and in weighing evidence, consider for a moment where such an assumption would land you, or rather strand you, in the sea of mathematics. If you have studied algebra, you have learned the supreme importance of assigning a definite meaning to every symbol. Each a, b, x, or y must be assigned a definite significance, and you must stick to that significance throughout any given mathematical deduction, or otherwise the value finally deduced will probably be erroneous. Ordinary syllagistic reasoning by the aid of language is essentially the same as algebraic deduction, so it is just as important to adhere to your definition of a word as to the meaning assigned to an algebraic symbol. Granting this, it follows inevitably that skill and care in defining words is essential if errors in reasoning are to be avoided.

Explanation has been variously defined, but almost every modern definition given by a logician will be found to agree substantially with the one framed by Jevons in his "Principles of Science; a Treatise on Logic and Scientific Method," p. 166: "Every act of explanation consists in detecting and pointing out a resemblance between facts, or in showing that a greater or less degree of identity exists between apparently diverse phenomena." He gives several examples of scientific explanation, e. g., "The marks upon a flagstone are explained when they are shown to correspond with the feet of an extinct animal, whose bones are found elsewhere."

In his "Logic," p. 346, Bain says: "The basis of all scientific explanation consists in assimilating a fact to some other fact or facts. It is identical with the generalizing process, that is, with induction and deduction."

Note that the example of explanation cited by Jevons fails to agree with Bain's statement that all scientific explanation is "identical with the generalizing process," for no generalization occurs when you infer that a given mark in a rock is a fossil footprint.

A scientific explanation always traces some effect to its cause. In this respect it resembles the explanation that a detective makes of a murder; but although a scientist always starts every research by considering some particular occurrence, and its attendant circumstances, his aim is to broaden his explantion so that it will become a scientific theory that will explain an entire class of phenomena, and perhaps many classes.

For the word "effect" we may substitute the term "resultant," and for the word "cause" we may substitute the term "component," and then we have:

A scientific explanation states a causé-effect sequence, or the resultant of component forces.

A scientific law may merely state a quantitative relationship, without explaining anything. Such were Kepler's three laws. But when Newton, guided by those laws, derived his theory of gravitation, he explained the Keplerian relationships as being due to the force of gravitation co-acting with the centrifugal force and inertia. Newton still remained puzzled as to why gravitation could seemingly act across empty space and produce a "pull"; but he did not publish any explantion of gravitation itself, but only of certain phenomena in which gravitation plays a part.

Bain, like Mill, is inclined to criticise Newton because Newton felt a need of explaining gravitation itself. In a letter to Dr. Bentley, Newton wrote: "It is inconceivable that inanimate brute matter should, without the mediation of something else which is not material, operate upon other matter without mutual contact." Mill ("Logic," p. 493) ironically says: "This passage should be hung up in the cabinet of every cultivator of science who is ever tempted to pronounce a fact impossible because it appears to him inconceivable."

Bain asserts that gravitation, being in a class by itself, will forever be inexplainable. Following Mill and Bain, the author of the article on Gravitation in Encyclopedia Americana says: "This independence of gravitation of any quality but mass, bars the way to any explanation of its nature or source." Observe that this inference is based on the doctrine that explanation always consists in showing to what class a phenomenon belongs; and since each class is determined by certain qualities, it follows that when any phenomenon has but one quality (e. g., the quality of mass) further explanation becomes impossible. But such a doctrine of explanation is incomplete, for if explanation consists in tracing effects to their causes, and if both effects and causes are always forces, it follows that explanations must go on indefinitely.

The history of natural science is little more than an account of the ways in which seemingly dissimilar things have been discovered to be similar, coupled with accounts of discoveries of the forces that produce certain phenomena or effects. When any two things are similar, it is because they display forces that are similar in intensity, direction and periodicity. Hence similarity is an evidence of quantitative likeness. But many similarities are designated as qualities, such as color; therefore many qualities are at bottom quantitative similarities. Indeed, it has long been suspected that all matter is composed of the same kind of ultimate particles whose motions alone determine the different kinds of matter. There has been a steady increase in the evidence that this is the case, so steady, and recently so rapid, that little doubt now remains that phenomena differ only in their difference in the number and motions of uniform particles. If so, ultimate explanation of any thing will be attained only when the interactions of the ultimate particles are fully understood. Ultimate or ideal explanation may never be attained, but it is important to understand the goal toward which science is running. It is highly important, for when a correct doctrine of explanation is entertained, no such brakes will be set upon the wheels of

scientific progress as Mill, Bain and other logicians would set. Speaking of gravity and "atomic impacts," Bain (p. 352) said: "Now there appears to be nothing in common to gravity and these atomic repulsions, except the result (i. e., motion). We have, therefore, no basis for assimilation or inductive generalization in such a comparison. The two modes of action must be allowed to lie apart in physical science; they must be embodied in different statements or laws, with no hope of being ever brought together. It is because gravity does not assimilate with the propulsion of impact from a blow or a stroke that people have accounted it mysterious. In point of fact, there is no more mystery in the one than in the other. Attraction, from great distances, is one form of the production of force; repulsion, at near distances (i. e., by impact), is another form. The last of the two is, on the whole, most familiar to us; it is the genus that our own physical force belongs to; and we, by mere whim, suppose it a simpler and more intelligible mode of exerting power; the truth being that, in all that regards simplicity and intelligibility, gravity has the advantage." So spoke Bain, the logician, but not so Newton, the scientist. Bain's doctrine of explanation closes the door to an attempt to explain gravitation, but Newton's mind remained uneasy to the last because he could not picture just how gravitation acts. He conceived an ether that somehow permits gravity to "pull," yet no ether that is easily penetrable by matter seemed capable of possessing tensile strength. But now that we know that matter possesses a mass that is measurable as "internal energy," and that energy is radiated, we can picture gravitation as being caused by the push of particles escaping in greater number from the far faces of any two bodies than from their near faces. Moreover, we can picture how such an asymmetrical escape of particles can be caused; for radiant waves from one body to another produce greater pressures on their near faces, thus causing greater escape of particles in the direction of least external resistance, which is in the direction of their far faces.

Ultimate explanation, it seems to me, relates solely to the impacts of ultimate particles that are identical. *The number, frequency, and position of such impacts determines the nature of every phenomenon.* This is why all phenomena are quantitative. It gives us the reason why mathematics is such a powerful engine of research. It teaches us the importance of observing every quantitative similarity between any two phenomena, however unlike they may be. It shows why logic must be wed to physical science, and must not stand apart merely as a verbal engine of reasoning. It shows why the boundaries between all the sciences are artificial boundaries.

Led by such a conception of nature and of our explanations of natural phenomena, we come to see that scientific theorizing is the most important work that men can do, excepting only the gathering of experimental and observational data with which to theorize and with which to show the degree of probability of any theory. Since a scientific hypothesis is but a tentative explanation, and a scientific theory is a highly probable hypothesis, it follows that science, both in its methods of solving problems and in its statements of the solutions, is little else than the art of explaining nature.

Survey to Be Made of Road Traffic in West

In order that the Federal Government and the Western States may know what the flow of traffic is throughout the year on the main transcontinental highways and on other roads in the Federal-aid highway system in the West, the highway departments of Washington, Oregon, California, Idaho, Nevada, Wyoming, Utah, Arizona, Colorado, New Mexico and Nebraska and the Bureau of Public Roads of the United States Department of Agriculture will make a traffic survey over a period of one year. The survey was started in September. Among the routes on which traffic will be measured are the historic Oregon Trail, over its entire length from Omaha to Portland, parts of the Santa Fe and Overland Trails, and the long-distance motor bus routes from Omaha to Denver, Salt Lake City and San Francisco, and from Denver to Los Angeles by way of Santa Fe, and from Seattle to Los Angeles.

The transcontinental highways which give easy access to National parks and monuments and to National forests in the West carry a great and increasing traffic from the East and Middle West, and they pass through public-land states which have large percentages of unappropriated and unreserved public land, relatively low densities of population, and comparatively small revenues for road construction, and in these States Federal-aid has been of material assistance in closing gaps in the through routes.

According to the National Park Service, United States Department of the Interior, automobile travel to the national parks has made tremendous strides in the last six years. In 1923 a total of 191,287 private automobiles entered 12 of the western parks; in 1928 the number was 439,049 cars, 129 per cent more than in 1923; and the 1928 figure for one of the parks was 420 per cent greater than the 1923 figure.

Data compiled by the State highway department of New Mexico in 1927 and 1928 indicate that more than 30 per cent of the vehicles using the roads of that State in those two years were from other States, and on many routes the so-called foreign traffic was more than half the total. The foreign traffic on many of the New Mexico highways was 50 per cent greater in 1928 than in 1927, and the total traffic was 22 per cent higher in 1928 than in 1927. A similar situation is believed to exist in the other Western States.

In these Western States traffic has reached the point where it is necessary for the States to know the flow of traffic density, and composition on their roads, so that they can plan their highway systems on a good economic basis and plan for the removal of snow in winter.

The survey will show the number of vehicles using each of the main highways throughout the year, by days of the week and hours of the day, and the number of vehicles passing a given point at certain times of the day. It will classify the traffic according to types of vehicles, whether passenger cars, motor trucks, or motor buses, and the number of passengers in passenger cars. The importance of cities, towns, and sections of the State as the source and destination of traffic will be ascertained, and the number of vehicles from other States using the highways, and other information required by State and Federal highway officials, will be obtained. The data will show population trends and will be useful in solving traffic regulation and safety problems. Surveys will be conducted simultaneously in each of the States.

Effective Road Illumination

Although tests recently made to determine the visibility distance with various types of automobile headlight beams indicate that, in the absence of approaching cars, the visibility is roughly inversely proportional to the cube of the distance from the source of intensity, the data tend to show that a change of at least 20 to 30 per cent in the intensity at the source must be made before the driver detects the difference.

These facts were reported by H. H. Allen, of the United States Bureau of Standards, at the summer meeting of the Society of Automotive Engineers, recently held at Saranac Inn, N. Y. Glare conditions have also been studied with various types of photometer, the latest development of this instrument being exhibited at the meeting. About 2,000 observations of present glare conditions by means of these windshield photometers show that a large proportion of the headlights encountered exceed by 100 to several hundred per cent the amount of glare point specified in a number of headlighting specifications. However, according to the findings, if two approaching cars are equipped with the same type and intensity of beam, the visibility distance is almost independent of beam intensity within wide limits.

Mountain Highway Locator's Instructions to Assistants

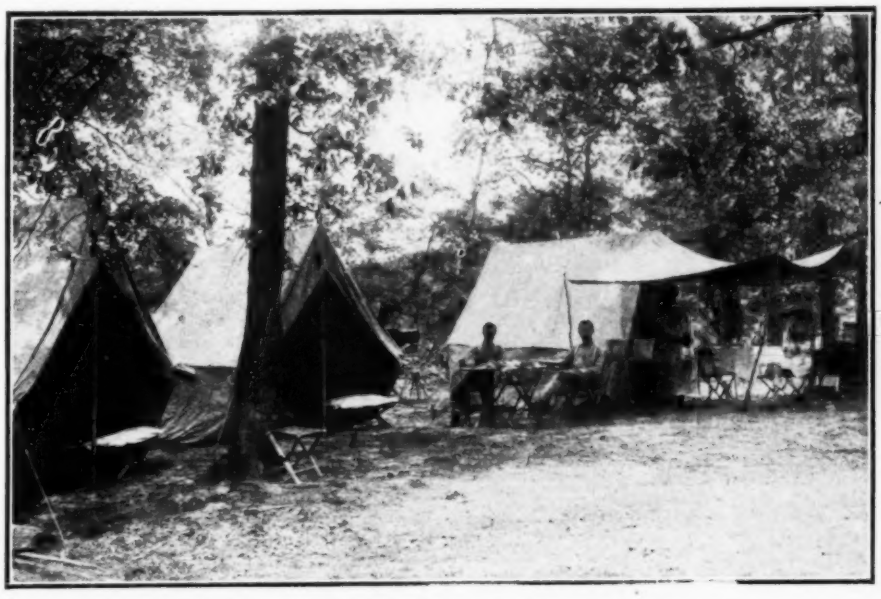
General Information to Field Parties Given In "Highway Location and Surveying"

IT has often been said that the most permanent thing about a road is its location. George E. Goodwin, formerly chief civil engineer, National Park Service, Department of the Interior, in a book by Col. W. W. Crosby, entitled, "Highway Location and Surveying," soon to be off the press by the publishers of ROADS AND STREETS, discusses this problem in relation to mountainous territory. The following information was abstracted from this book.

The way in which the various parts of road location surveys should be made and the necessary party, equipment, etc., will of course, depend entirely on a great many affecting conditions. These instructions, however, with regard to field surveys of mountain roads are presumed to be more or less general and to apply to the topographical, timber, and geological conditions which will be found in most of our Western national parks and in a mountainous area more or less removed from the roads and where transportation of supplies, etc., can only be by pack outfits.

Examinations and field surveys can usually be divided into preliminary examinations and reconnaissance, detailed preliminary surveys, final surveys, and construction surveys, and they will be taken up in this order herein. How each class of surveys will be conducted must of necessity be governed by the time and funds available and the road standards adopted, as well as by the physical and other existing and controlling conditions.

Studies and Preliminary Reconnaissance.—Before field surveys are actually run out or undertaken, the field engineer in charge should make such studies and preliminary examinations as will make him more or less generally familiar with the country in which the road is to be built. He should consult the maps, and especially U. S. topographical maps, if obtainable; travel over as many of the possible road routes, either by foot or horseback, as time and conditions will permit, viewing them with regard to the difficulties of the work and the other things affecting the cost, such as topographical, geological, timber, and hydrographic conditions, etc., together with the extent to which the road will meet the desired conditions; and above all, its scenic and developing possibilities, all of which are necessary for a preliminary understanding as to where the most favorable road locations are apt to be found. Much country can be hurriedly covered and a pretty good idea as to its topography and elevation secured by the use of an aneroid barometer, a hand level and a clynometer. Some information can often be obtained from local residents. The engineer is, however, especially warned against taking too seriously the opinions and statements of the so-called "old timers." Their judgment is invariably wrong and the historical information which they give is seven times out of ten incorrect.



The Camp—An Important Part of Highway Location

Preliminary Location Surveys.—Assuming that a general knowledge of the country has been secured from studies of maps and by personal examination and a more or less general idea as to about what general route should be followed by the road, the engineer is in position to make the actual reconnaissance surveys necessary for a comparison as to feasibility and approximate cost of the different routes.

The actual reconnaissance survey is usually made in the field by the engineer in charge. This, in general, consists of a clynometer line which is carried along at the approximate desired grade, decision being made as to probable control points, general changes in direction, stream crossing, and a preliminary decision must be made as to how these different physical obstacles will be overcome. It will often be found advantageous to run two or more clynometer reconnaissance lines, noting the topography and geological conditions and difficulties of each, as well as the various scenic attractions developed, in order that decision may be made as to the best route. On this reconnaissance line the engineer will decide what appears to be the best way of passing through the various critical or controlled points and decide, in general, where the preliminary location shall be made. Clynometer lines can be run by the engineer alone, but faster work will be done if he is assisted by another man who will help him blaze the line where it is through the woods, or stick stakes or pile rock cairns in open stretches. Trees should be lightly blazed (that is, blazed so they will show a mark about 1 in. to 2 in. in diameter only) and at frequent intervals so that the line can be readily followed. Promiscuous and heavy blazing should never be done along the reconnaissance lines. In a country covered with thick, low brush, small poles can often be stuck up, or rock cairns or ducks built, or sticks stuck in open or grass land. Clynometer lines, if carefully run, are very accurate and, with consideration given to curvature, etc., which will have to be made, it will be found that the preliminary transit line will follow the clynometer line very closely.

Party—Duties and Responsibilities.—The party and duties of the men for the preliminary location surveys will depend, of course, on the amount of work to be done, the time and funds

available and the nature of the country. Under ordinary conditions the total party would consist of perhaps eight to ten men, being locating engineer or chief of party, transitman, levelman, a special rodman, two chainmen, one or two axemen, a cook and sometimes a packer.

The ENGINEER'S duties would be to have general charge of all administrative and field work, to make the preliminary studies, run out the reconnaissance clynometer lines, run the camp, direct all operations on the survey and hire and discharge the men occupying minor positions and make recommendations and reports relative to other employes, report the work and keep a cost record of same.

The TRANSITMAN'S duties will be to run the transit, keep the notes, check them, plat the line, and do such other work as the engineer in charge may direct, and in the absence of the chief of party or locating engineer he will take charge of the work and act for the engineer in all matters. He will be personally responsible for the use and protection of the transit and its supplemental equipment.

The LEVELMAN will run the level, keep level notes, check them, plat the profile, reference in the line, take topography if directed, and carry out the instructions given by the assistant engineer, and in the absence of the assistant engineer and transitman will be in charge of the survey. He will be personally responsible for the use and protection of the level, etc.

The SPECIAL RODMAN will have no regular duties, but will do such work as is assigned to him from time to time by the assistant engineer, whether that be checking notes, making comparative estimates of costs, or doing field work in a minor capacity. He is usually considered as supernumerary, and should be able to run a hand level, a clynometer, record notes or, in fact, work in almost any capacity except that of transitman and he might well be an understudy to the transitman.

The RODMAN'S duties are to assist the levelman in profiling the line or taking cross-sections. He will be responsible for the use and care of the level rod, and such other tools as are given him.

The HEAD CHAINMAN will be responsible for the use and care of the chain and the range pole used. The rear chainman will be responsible for the metallic tape, plumb bob, and such other tools as are given him. The stakeman will be required to see that ample stakes are on hand, that he is supplied with marking keel, and he will be responsible for the stake sack and stake ax. His duties will be to mark and drive the stakes and do such other work as may be assigned to him. The axeman, if only one, will usually act as head flag, in which case he will not only be responsible for the ax, etc., given him, but also for the picket which he uses. His duties, of course, will be to brush out the line, and do such other work as assigned.

None of the men in any of the above listed or unlisted positions will be considered as having any special duties which would exclude them from doing any work which is necessary for the proper progress of the survey, or which they are directed to do by the man in charge of that party or by the engineer in charge.

Equipment.—The equipment necessary for preliminary location surveys will, in addition to the necessary camp and mess equipment, consist of a transit, a level, one or two clynometers, one aneroid barometer, one or two hand levels, two 100-ft. chains, two or three metallic tapes, two level rods, two range poles, several axes, usually a paint brush for the painting of trees and certain other miscellaneous camp and line equipment. The equipment will, of course, vary somewhat in accordance with the size of the party and the nature of the work to be undertaken.

Method.—The method to follow in preliminary surveys will depend on the results sought and the country through which the survey is to be made, as well as the funds and time available. In general, however, it is assumed that the preliminary location will follow the gradient or reconnaissance lines previously run out by the locating engineer and that the preliminary location will be run out with a transit; staked on the ground; *PI's* set; certain of the *PI's* referenced in; curve radii determined; curve lengths determined; *PC's* and *PI's* set; stations set at least every 100 ft.; the line profiled at each station and oftener as needed to determine the ground breaks; and that the transverse slopes will be determined for the probable construction distances on either side of the line (these slopes will be determined by either a clynometer or hand level); that the timber growth, the clearing and grubbing, etc., will be classified and the areas estimated; that the nature of the materials to be moved in excavation will be determined, and that data necessary for estimating the cost of bridges and other structures will be secured.

Time and Output.—The amount of time necessary to make preliminary road location surveys depends, of course, on the difficultness of the country, the size of party and the thoroughness with which the work is done. Generally, with a party as outlined above and topographical and timber conditions such as are found in high mountain country, from one-quarter to 1 and one-half miles (averaging about one-half mile) of line per day can be staked out and profile and topographical and classification and structure notes secured, the amount, of course, varying in accordance with the difficultness of the country. In thick, high, and large brush and broken country, requiring continuous curvature, progress will be slow. Where *PI's* will average 500 feet or so and little brush cutting is required, one and a half to two miles should easily be obtained by an experienced party.

Shifts in Pennsylvania Highway Staff Made to Carry New Program

Reorganization of the Pennsylvania Department of Highways in anticipation of the launching of a comprehensive construction program made possible by the recent enactment of legislation, agreed upon by Governor John S. Fisher and Secretary of Highways James Lyall Stuart has been announced.

The reorganization is intended to strengthen the service of the department so it may cope with the added duties imposed by recent legislation.

Construction work throughout the state will be supervised by C. H. Buckius, division engineer at Scranton, now in charge of Susquehanna, Wayne, Wyoming, Lackawanna, Luzerne, Pike, Monroe, Carbon, Northampton and Lehigh counties, who became construction engineer in the headquarters at Harrisburg. Maintenance construction will be supervised by two assistant maintenance engineers, one in charge of the eastern half of the state and one in charge of the western half. C. A. Eichelberger, equipment engineer at the Harrisburg headquarters will be assistant maintenance engineer for the west, and D. C. Stackpole, division engineer at Philadelphia, in charge of Berks, Bucks, Montgomery, Chester, Delaware and Philadelphia counties, will be the assistant maintenance engineer in charge of the east.

C. C. Albright, assistant township engineer, has been promoted to township engineer, vacated by R. V. Warren of Pittsburgh, resigned. S. P. Longstreet, division engineer at Harrisburg in charge of Mifflin, Juniata, Perry, Dauphin, Cumberland, Lebanon, Lancaster, York, Adams and Franklin counties, has been transferred as division engineer to Scranton, replacing C. H. Buckius, transferred to Harrisburg, J. C. McCarrell, now assistant division engineer in Harrisburg, is promoted to the post of division engineer in succession to Mr. Longstreet. W. D. Myers, division engineer at Hollisdaysburg in charge of Indiana, Cambria, Blair, Huntingdon, Somerset, Bedford and Fulton counties, is transferred to the office of division engineer at Philadelphia, succeeding Mr. Stackpole. H. E. Kloss, assistant engineer at Clearfield, is promoted to the position of division engineer at Hollidaysburg, succeeding Mr. Myers.

The Basic Elements of Street Traffic Control

A Discussion of the More Important Feature of the Control and Regulation of Traffic

By C. E. DE LEUW
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PROPOSITIONS for the improvement of traffic conditions, for facilitating the movement of street traffic and for promoting safety may be separated into two general classes, as follows:

(1) Improvements through regulation using means and devices which involve no major expenditure of funds and which operate to afford the full utilization of existing street systems, and

(2) Major improvements involving the expenditure of large sums of money for widening roadways, separating grades at street intersections, elevating or depressing railroad tracks, constructing two-level streets and the like.

Confining our attention for the moment to those regulatory measures which seek to develop to the utmost the existing street facilities, we find that the more important of these may be listed as follows:

(1) Restriction of turning movements,

(2) Restriction of parking,

(3) Establishment of through streets or boulevards,

(4) Installation of traffic control signals,

(5) Regulation of the operation of mass transport facilities,

(6) Regulation of pedestrian movements, and

(7) Construction and maintenance of smooth pavements.

Turning Movements.—One of the most troublesome obstructions to the free movement of vehicular traffic is the left turn. Vehicles making left turns cut across the path of and obstruct all vehicles moving in the opposite direction or, while awaiting an opportunity to make the turn, block all vehicles in the lane directly behind them, thereby reducing the useful capacity of the roadway by one lane. The elimination of left turn movements from highly congested areas or from heavily traveled roadways is frequently warranted, the Chicago Loop District being a notable example. However, unless volumes of traffic have increased to the stage where relief is absolutely necessary, the wholesale elimination of left turn movements should be approached most cautiously.

Right turns do not, as a rule, affect the free movement of vehicles. They do, however, offer a particularly troublesome problem at cross walks where the flow of pedestrian traffic is heavy. There are special intersections and special areas in some of the American cities where right turns have been entirely prohibited. This is true of several intersections in the central business district of Los Angeles where the movement of pedestrians is noticeably heavy. The most recent example of right-turn prohibition on a large scale is in the theatre district in New York. New regulations affecting traffic movements in this highly congested area were placed in effect in February, 1929, and these have been very beneficial in facilitating the movement of both vehicular and pedestrian traffic. The elimination of right turns in the district bounded by 5th Ave., 9th Ave., 41st St. and 51st St. is included in these measures. No counts of pedestrian traffic in the theatre district are available but observation leads to the belief that the sidewalks in this area are more congested between 7:30 and 11:30 P. M., than at any other place in America. The prohibition of right turns was believed warranted and experience has proved this to be a fact.

We frequently find that U-turns, or those involving a 180-degree change in direction, are prohibited. In Chicago these turns are permitted between street intersections provided they do not interfere with the free movement of other vehicles, and this regulation is believed to be sound. The complete elimination of U-turns, particularly in areas where left turns are prohibited, would result in an unnecessary amount of travel and consequently greater use of the street system to no particular advantage.

Restriction of Parking.—The question of parking, how to park, when to park, for what period, and in what places, is one phase of traffic control on which there has been the most discussion. It is a question that affects practically everyone. There are special interests such as shops and stores in shopping centers which have in some cities, come to consider it almost a life-and-death matter. While some clear thinking has been done on this subject the waters have been muddied repeatedly by people with special interests. The problem has been to find some one with expert knowledge who was, in fact, really disinterested. Volumes have been written on the subject and experts have calculated the capitalized value of the space occupied by parked vehicles down to the last dime. As a matter of fact, the problem is relatively simple. The Chicago experience definitely proves this to be the case.

All-day storage of vehicles on the streets of any business center worthy of the name is almost never warranted, unless excessive roadway widths have been specifically provided for that purpose. Limited parking for the purpose of transacting business of one kind or another up to periods of 30 or 60 minutes is warranted:

(1) Where the width of the roadway remaining for the free use of moving traffic is sufficient to accommodate its needs without congestion or uncomfortable crowding.

(2) Where parked vehicles do not monopolize space at the curb necessary for the use of vans or delivery wagons making service stops either for the purpose of loading or unloading goods, and

(3) Where parking will not interfere with the provision of adequate safety zones for the accommodation of street car passengers at and near street intersections, or with the free movement of vehicles at street intersections.

Chicago is the first of our large cities to eliminate parking on the streets of the central business district during the business day. The improvement in condition is obvious. Not all of the improvement, however, can be laid to parking restrictions, as the rerouting of street cars, the elimination of left turns and the operation of co-ordinated traffic signals have also been important factors.

The logical solution of the parking problem rests in the development of a sufficient number of off-street storage places to provide all parking facilities needed at a reasonable cost. There should be no objection on the part of individuals who prefer to operate individual transportation units (vehicles accommodating from one to four passengers but generally an average of less than two) to paying the actual cost of storage of their vehicles plus a reasonable profit. In a number of cities storage facilities are provided by the municipality at cost and garages, constructed and operated by private individuals, are nearly always available for the use of those who prefer to ride to and from the business district in their own motor cars.

Chicago is probably in the lead in providing facilities for storage of automobiles in and near the central business district. In Grant Park, the South Park Commission has provided storage space

for 4,200 automobiles in an area readily accessible to the east side of the central business district and for a nominal charge. The construction of two-level Wacker Drive has afforded free parking space on one edge of the central business district for 2,000 automobiles. The utilization of this surplus space, pending the development of vehicular traffic to the point where all of this space is required for moving traffic, is, of course, fully warranted. That this improvement is an uneconomical one from the viewpoint of providing parking space only is evidenced by the fact that the entire Wacker Drive improvement cost about $20,000,000 or $10,000 per vehicle stored.

One of the most significant developments growing out of the passage and enforcement of the "no parking" ordinance during the past fifteen months is the multiplication of private garages in and near the central business district. The garages in the district bounded by Harrison St. and the Chicago River have a total capacity for approximately 6,000 automobiles, which may be contrasted with the maximum storage space on the streets in this area for about 2,300 vehicles which was available, except during rush hours, before the passage of the parking ordinance.

Construction of other storage facilities in office buildings, such as the Pure Oil Building, with automatic equipment for the handling of vehicles is, in the opinion of the writer, a good indication of what may be expected in providing parking space in the future in highly congested areas. It is predicted that within the next 15 years most of the new buildings constructed in such areas, either for office buildings or department stores, will be provided with like facilities. The provision of space and equipment, which will permit a man to drive into the basement of a building, turn his car over to an attendant, have the car go up in one elevator while he rides up in another, may become the standard construction a generation hence.

Through-Streets and Boulevards.— The idea of designating certain preferential streets, originated in Chicago on the boulevard systems. A vehicle entering the preferential street ("through-street" or "boulevard") is required first to come to a full stop. The development of this idea has been rapid and widespread. When logically planned a system of through-streets and boulevards is a decided aid to the proper and expeditious handling of traffic. Certain streets, by reason of their continuity, location and sometimes by reason of operation of mass transportation facilities thereon, carry volumes of traffic much larger than nearby parallel streets. When the volume of traffic on such arteries reaches the point where there is practically continuous movement along them, the designation of the artery as a through-street is warranted. There are isolated instances where creation of through-streets is warranted to provide relief facilities for adjacent parallel streets which have become overloaded with traffic.

Through-streets are popular. Motorists enjoy driving on them because they are given a measure of protection from entering and crossing traffic and are enabled to make higher crest speeds and higher over-all average speeds, due to less frequent interruptions. This has frequently led to the designation of too many through-streets. Many through-streets have been designated in localities where neither the continuity of the route, condition of pavement nor volume of traffic has warranted the preferential designation. This condition, where it has been allowed to develop, is vitally important from the viewpoint of safety. Experience has proved that motorists will respect a through-street or boulevard stop sign only as long as the volume of traffic on the through-street makes it unsafe to do otherwise. It has been found, therefore, that the stop sign is seldom observed on through-streets where the volume of traffic is light. The dangers surrounding such a condition are obvious. Motorists on such through-streets expect all entering vehicles to make a stop before crossing the street and failure to do so frequently results in serious accidents. As a general proposition no street should be protected with through-street or boulevard stop signs until a thorough survey of the situation is completed and a recommendation is made by some properly qualified expert.

For those streets and intersections which do not have sufficiently heavy traffic to warrant their designation as through-streets but which do, on the other hand, have sufficient traffic at certain times to require some warning sign, a "slow" sign will generally suffice to prevent accidents. These signs are installed near the intersection to be protected. This sort of regulation accomplishes the desired end, in that it is reasonable and is observed by practically all drivers of vehicles, in contrast to the failure of such drivers to observe stop signs at unwarranted through-streets.

Traffic Control Signals.—Manual and whistle signals were the first means used to control traffic and in some places still remain the principal means of control. The next step in traffic signaling was the development of semaphore signals, more or less crude affairs, generally manually operated by the traffic officer. Within recent years automatic signals have been installed in the great majority of cities throughout the country. The use of the automatic electric signal has become so widespread and their effect on traffic movements so important, that thorough studies should always precede their installation.

The automatic signals in use today fall into one of three classes as follows:

(1) Isolated signals with operating mechanism for control of the signal lights at a single intersection with no reference to control at adjacent intersections neither as to length of cycle, nor as to movement of traffic.

(2) Signals at a group of intersections synchronized through the operation of a master control providing for uniform cycle and for all signals showing the same color in the same direction simultaneously, and

(3) Signals at a group of intersections connected with a master control with uniform length of cycle but with timing arranged so as to bring about non-stop movements at given rates of speed on the streets in the area signaled.

The use of uncoordinated signals at isolated intersections is sometimes warranted in the intermediate or outlying sections of a metropolitan district. The intersection of two through-streets, of a through-street with a boulevard, of two boulevards, and other intersections where the density of volume of traffic is such as to produce a condition approaching the continuous uses of the roadway, are examples of intersections where the use of isolated signal control may be warranted.

Where intersections to be signal-controlled are within 2,000 ft. of similar intersection the signal should be hooked up into a system under master control and so timed as to produce a continuous movement for traffic groups with as high a speed as may be consistent with safety.

Signals Increase Safety.— Signals provide for orderly movement of traffic at intersections and, when properly installed at intersections having sufficient volume of traffic to warrant them, add greatly to safety. It must be remembered, however, that the installation of signals of any type operates to set a limit on the time during which traffic at the intersection can move either north and south or east and west. It must also be borne in mind that the installation of signals at intersections, where there is no continuous flow of traffic, will breed disrespect for the signal regulations and invite infractions of the same. Any law or traffic regulation really is enforceable only so long as it appeals to the majority of citizens as being reasonable.

Operation of Mass Transportation Units. — Mass-transport units, both street cars and motor buses, are affected by the regulation of turning movements, establishment of through-streets and installation of traffic control signals in the same way as all other vehicles using the streets. When considering the elimination of left turns in congested areas, study must first be given to the operation of mass-transport units to determine whether it is practicable to eliminate left turn movements from the operation of these

public facilities. In many cases it has been found possible to reroute street car lines and motor bus lines so as to eliminate the great bulk of left turn movements in congested areas. This was done in Chicago and was a necessary preliminary to the elimination of all left turns in the loop district.

The average motorist is inclined to regard street cars and their operation, particularly on narrow roadways, as an unmitigated nuisance. This comes from the fact that he is prevented by law from passing a standing street car. Failure to provide safety zones for loading and unloading passengers at street car stops, coupled with failure to restrict parking adjacent to such safety zones, results in stopping all traffic at street car stops. Many street car streets have a roadway of sufficient width to provide for six lanes of traffic. At street car stops, the street car occupies the inside lane, parked vehicles occupy the outside lane, and the center lane is partially filled with passengers about to board or those who have just alighted from street cars. Obviously, no other vehicles can pass the street car. When, coupled with these conditions, there is a rough pavement, passing of street cars in movement is well nigh impossible and the speed of all traffic is throttled down to the average speed of the street car. The solution lies in the provision and maintenance of smooth pavements, the establishment of safety zones for the convenience and safety of patrons of the street car lines, and the prohibition of parking adjacent to such zones; thereby providing a lane for the free movement of vehicles between the safety zone and the curb.

The movement of each class of vehicles operating on a roadway affects the movement of all other classes to some extent. Street cars making frequent and unnecessary stops serve to retard the movement of all other vehicles. The writer has engaged in studies in cities where street car stops were the same number as at the time of the first operation of horse cars. Where the blocks are short, lines have been found with as many as sixteen stops per mile. There is no sound reason for providing more than eight stops per mile, except in business districts. The rearrangement of stopping places so as to provide about eight stops per mile will serve to accelerate street car operation and, in a measure, the speed of all vehicles operated on the street. Such a program was put in effect in Chicago over eight years ago and the operation of the Chicago Surface Lines at the present time is almost a model as respects speed, the average speed being higher than that obtained on practically any of the large transportation systems in the country.

Regulation of Pedestrian Movements.—Another regulation about which there has been much argumentative discussion among students of traffic matters is the question of pedestrian control. When automatic, electric, 4-way signals are installed at the four corners of an intersection so that they can be readily seen by all pedestrians, the control of pedestrian traffic is greatly facilitated. It has been observed that, without regulation by the police, about two-thirds of the pedestrians voluntarily await the green signal before crossing the roadway, where the number of pedestrians moving on the sidewalks and crosswalks is not excessive and where obstructions offered by vehicles making right-turn movements are not too frequent, the absolute enforcement of the rule that pedestrians shall obey the signals may be practicable. Pedestrian control, where practicable, greatly facilitates the movement of vehicular traffic.

In Los Angeles, the first city of any size where pedestrian control was enforced, the improvement in traffic condition was striking. It is not a particularly popular regulation. The average citizen resents being told when and where he is allowed to move. Ordinarily he has no objection to standing on the sidewalk until a procession of moving vehicles passes, but, after all vehicles have passed, he does object to being required to await the expiration of the red signal interval.

Pedestrian regulation, to be successful, requires that the signal cycle be short. If the cycles are short enough to limit the red signal to the time actually required by moving vehicular traffic, pedestrian regulation will operate effectively.

In highly congested areas, such as the loop district in Chicago and the mid-city business and shopping district in New York, the volume and density of pedestrian traffic is so great as to make the enforcement of pedestrian control by signals impracticable, if not impossible. In these districts the great number of pedestrians requires that their movement be given first consideration. If pedestrians in such districts were required to move with the signals and if right turning movements were permitted, an almost hopeless confusion would result. Observations, made at typical intersections in shopping districts in Chicago, disclose the fact that the majority of time in the signal cycle is frequently taken up by vehicles making right-turn movements. When half of the green interval is taken up by vehicles making right-turn movements, only about fifteen seconds out of each minute remain for the movement of pedestrians across roadways, which is, obviously insufficient where sidewalk congestion approaches a state of saturation.

Pedestrian Traffic Control.—The new regulations in the theatre district in New York City include the absolute enforcement of pedestrian movements with green signals. Right-turn movements of vehicles are also eliminated. The regulations work well. It is rather significant, however, that an additional force of some five hundred police officers is required to make the new regulations effective and most of these officers are occupied in the matter of pedestrian control. At the intersection of 7th Ave., Broadway and 45th St., twenty-five police officers, including one sergeant and one lieutenant, were observed to be on duty. This is indicative of the difficulty of enforcement of pedestrian control on sidewalks accommodating large crowds of people.

The model traffic ordinance, and in fact most traffic codes which have been written in the last few years, clearly define the rights of pedestrians on streets and roadways. Most of these codes require that pedestrians cross roadways on cross walks marked along the sidewalk lines extended. This is a sensible regulation and has resulted in decreasing accidents.

It may be concluded that the enforcement of pedestrian movements with the green signal is practical, except in highly congested areas where it should not be enforced unless accompanied by complete prohibition of right-turn movements of vehicles.

One-Way Streets.—The matter of creating one-way streets is one requiring special study. In general, the disadvantages of one-way street operation are found to outweigh the advantages. Some streets are so narrow as to make the operation of two-way traffic on their roadways inefficient. Wherever the width of roadway is such as to require all vehicles moving in either direction to follow in single file, all traffic will be slowed down to the speed of the slowest vehicle. On such a roadway the efficiency may be increased somewhat by one-way operation.

While under certain circumstances the speed of traffic on one-way streets may be greater than that on two-way streets it is generally an inconvenience to the public and sometimes a disadvantage to the merchants. A more circuitous route is required to reach a given destination, and this has the effect of increasing the number of vehicles operating on the street system. Usually, vehicular traffic must conform to the routing of street cars and it is frequently impracticable to change the routing of street car lines in order to provide a few one-way streets. If a change from two-way to one-way street operation were attempted in an area where street cars operate on practically every street in both directions, it would result in decreasing the street car track capacity by approximately 50 per cent. One-way streets must be laid out in pairs (unless intended to meet an unbalanced or rush hour condition), otherwise an unbalanced street system will result. There are so many factors which enter into the question of one-way street regulations, that very care-

ful study should always be made before such regulations are adopted.

Other Traffic Control Measures.—Many proposals for curing traffic ills have been made, other than those described above, the most important of which are as follows:

Restriction of delivery of coal and building material to certain off-peak hours,

Segregation of traffic and, in particular, the restriction of horse-drawn traffic to certain streets,

The provision of properly located taxicab stands and the elimination of cruising,

The restriction of excavations for the construction, reconstruction or repair of underground structures,

The elimination of all unnecessary obstructions to traffic, such as piles of building material and the like,

The construction of pedestrian tunnels across highly congested traffic arteries, and

The construction of elevated walks and crossings for the use of pedestrians.

Practically all of the above measures are practical and when justified by local conditions should be effectuated.

The question of proper construction and maintenance of pavement is possibly outside the scope of a paper dealing with street traffic control. As a matter of fact, however, there is no one single factor which contributes as much to the safety of the users of the streets, their conveniences and the acceleration of the movements of vehicles, as maintenance of smooth pavements with moderately low crowns. Difficulties of proper maintenance are increasing because of the frequent ripping up of pavements in congested business districts and the failure of the utility company or city department, making the excavation, to restore the pavement properly upon completion of its work. This also is a subject outside the scope of this paper but important in its effects on street traffic none the less.

Acknowledgment.—The foregoing is an abstract of a paper presented before the Western Society of Engineers.

The 1930 Convention and Road Show

Great progress in the development of highway construction and maintenance machinery is evidenced by the increased number of applications for exhibition space that are being made for the next convention and road show of the American Road Builders' Association, which will be held in Atlantic City in January, 1930. To date 14 per cent more applications have been received for space than at this time last year, this in spite of several mergers in the exhibitors' field. Many of the applicants have not heretofore exhibited at this exposition and some are new companies that are just entering into the highway industry.

Almost every exhibitor is bringing forth some new idea or feature and the year will mark great strides in the showing of new labor-saving equipment.

Within the new auditorium and its exhibition hall, the largest in the world, the exhibitors, for the first time will be able to assemble and completely demonstrate their road building products in one building.

Hotel accommodations will be manifold with plenty of spacious and luxurious rooms available at special low prices granted to the road builders.

Manufacturers of road building equipment and materials will display over 500 carloads of their products. This will be the largest exposition of this nature that ever has been held. It will be so arranged and coordinated with the convention that delegates may attend all sessions and yet have sufficient time to see and compare all the different makes of machinery and materials. Several machines never before shown will be on display. Practically all of the standard and patented pavements will be represented.

A survey by the reservations committee of all sections of the United States and the Central and South American countries indicates general representation by larger delegations than ever before.

The first day of the Road Show, Saturday, Jan. 11, will be Manufacturers' and Distributors' Day. The show is not to be opened to delegates in general on this day but given over to the manufacturers in order that they may confer with their distributors and give the show a final once-over before the hosts of engineers, highway officials, contractors and foreign delegates arrive.

Monday, Jan. 13, is the grand opening day for the public and a general session of the convention will be held in the Auditorium ball room. The convention session will be opened by men of national reputation and a short ceremony will follow.

There are nearly fifty committees working on subjects of prime importance to road builders and these committees will meet and present their reports during the convention days. Everyone is invited to attend any committee session in which they may be interested, but members of the committee only may vote on standards.

The committees on highway finance, lien laws, standardization and depreciation of equipment, municipal airports, legislation, grade crossings, traffic and subgrades and pavement bases are among those who will make reports.

Wednesday, Jan. 15, will be Pan-American Day and a general session will be held in the music hall. This program will be carried on by the Pan-American Division. Officials from the Latin-American countries will take part and tell of the road conditions and road programs in their countries. Most of the ambassadors and ministers from Latin-America will go up from Washington for this event. In the afternoon the Pan-American Division will meet for business discussion.

The great Road Builders' banquet will be served in the Ambassador Hotel Wednesday evening, with places limited to 1,500 and a "Road Builder" of renown as chief speaker.

All committee reports will be completed and presented Thursday, and that evening the International Ball will take place in Music Hall for members of the American Road Builders' Association and delegates from outside the United States only.

Friday, the last day of the exposition, will be given over entirely to the inspection of equipment and materials.

Southwest Road Show and School

February 25, 26, 27 and 28, 1930, are the dates set for the fifth annual Southwest Road Show and School, to be staged at Wichita, Kans.

The educational program will be arranged under the supervision of the Kansas State Highway Commission and Kansas State Agricultural College in co-operation with the highway commissions of the southwest states, the United States Bureau of Public Roads and various colleges and universities.

This show and school has attracted the attention of the entire southwest to the extent that 9 states surrounding the place of meeting, not including colleges and universities, had exhibits at the last school. At this early date, many have signified their intentions of exhibiting at the 1930 exposition.

Arrangements are being completed for additional floor space to take care of the machinery, equipment, accessories and material exhibits, which last year taxed the exhibit space to its limit. It is anticipated that the attendance will exceed 25,000.

Gravel Sizes.—The Board of Directors of the National Sand and Gravel Association met in Toronto, Ont., on May 17, 1929, and voted unanimously in favor of an effort to simplify sizes of screened gravel. Recommendations along this line had already been tentatively formulated by the Standardization Committee of the Association. With the approval of the Board of Directors, the Standardization Committee will proceed at once to circularize the entire membership of the Association, also non-member firms in the industry, to secure approval of the recommended standards. When such approval has been received from firms representing at least 80 per cent of the volume of production, the Standardization Committee will be authorized to request the Division of Simplified Practice of the U. S. Bureau of Standards to call a general conference of producers, distributors and users of gravel, to act upon the recommendations.

A Review of Vehicle Toll Bridge Field

Earlier Structures—Toll Bridges in United States—Type—Franchises—Rates of Toll—Methods of Financing—Outlook for Future Legislation

By P. K. SCHUYLER
President, Federal Bridge Co., New York

THE revival of the vehicle toll bridge which has been taking place in the last few years has opened up problems of debatable possibilities. The rapid increase in the number and uses of motor vehicles has created a sudden demand for highway facilities that will save distances and time for motorists, and highway bridges have been the result in many cases of the demands of the motoring public. The problems regarding highway bridges that the country is now faced with are ones of economics and necessity; shall these bridges be free or toll, and shall they be built by state or private interests. In order to attempt to arrive at correct conclusions with regard to these problems it is desirable to have a knowledge of the past history of toll bridges and of the present situation and trend of developments.

Early Toll Bridges.—Toll bridges as means of furnishing transportation facilities date back to very ancient times, and there are records of such bridges having been in existence in Asia and the European Continent many centuries ago. The first of these bridges that we read about were built and operated by various orders of Monks, who constructed them as a public service and collected a small toll for crossing. In the United States the first toll bridge of record was across the Newberry River at Rowley, Mass., and was built in 1654. A franchise was granted in April, 1757, by an Act of the House of Burgesses of Virginia authorizing the construction of a private toll bridge across Pagan Creek in Virginia, which was constructed the succeeding year. In 1786 there was a toll bridge constructed between the cities of Boston and Charlestown, Mass. A short while later in the year 1790 a privately owned toll bridge was built across Spuyten Duyvil Creek connecting Manhattan Island with the mainland. Records further show that by the year 1828 there were more than twenty companies operating toll bridges in New York state alone. Along with the construction of toll bridges in the early half of the Nineteenth Century, there were constructed a large number of toll roads, the turnpikes of Pennsylvania being an example of such construction. These toll roads and bridges during the Nineteenth Century pros-

Fig. 1.—Toll Bridges of the United States, Proposed, Under Construction, or in Operation on Oct. 1, 1927

pered, but in small degrees because travel by highways was greatly restricted, the bulk of transportation facilities of the country at that time being furnished by railroads, and the number of toll bridges gradually decreased. With the beginning of the Twentieth Century automobile transportation developed, and there was a great impetus to the construction of highways, thus many of the old toll bridges which had been operated by the owners at a loss or with a very scant margin of profit suddenly turned into very profitable and remunerative propositions. The examples furnished by these successful toll bridges served to induce capital and enterprise to construct additional structures, and hence the present era of toll bridge expansion was begun.

Two Hundred and Seventy-two Toll Bridges in United States.—A tabulation of the number of toll bridges and toll bridge projects in the United States or on the international boundary shows the following conditions:

	Number of Toll Bridges		
	In Operation	Under Construction	Proposed
Oct. 1, 1927*.....	238	24	163
July 1, 1929**.....	272	60	294

* Data from Survey Bureau Public Roads.
** Data from files Federal Bridge Company.

In the interval from Oct. 1, 1927, to July 1, 1929, there were 73 new toll bridges placed in operation and 34 toll structures freed, making an additional number of bridges in operation of 39. In the above tabulation a toll bridge is considered to be proposed when some definite steps have been taken regarding it, such as obtaining or making application for a franchise or organizing a company. There is at the present time invested or contemplated for investment in toll bridges, including both public and private interests, an estimated amount of $1,100,000,000.

Types of Toll Bridges.—Toll bridges are of many and varied types. The kind of bridge constructed varies according to the nature and characteristics of the country and of the travel which is to use the bridge. Bridges in the south and southwest are frequently designed for very light loads and use is often made of a light type of suspension bridge, whereas in the east and middlewest traffic conditions warrant the construction of a heavier structure.

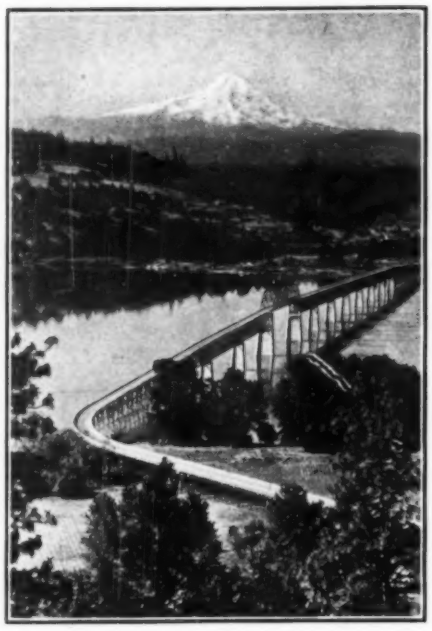

Fig. 3—Toll Bridge Over the Columbia River at Hood River

Toll Bridge Franchises.—The matter of toll bridge franchises is a rather involved one and there are many points in regard to these franchises which are contestable, and upon which it is necessary that the Supreme Court pass before definite conclusions can be drawn. The original source of power to build bridges was vested in the various individual states from which sources titles to all land originated. The Federal Government, due to the Commerce clause in the Constitution, which gives the government power to regulate commerce between the states acquired certain rights and powers of control over the building of bridges. In 1906 Congress passed a general bridge act under the authority of which act all bridges requiring Federal consent are now constructed. For each bridge to be constructed over water that is navigable in two states, authorization in the form of a separate act of Congress is required. After obtaining authorization from Congress for the construction of a bridge, whether it be a toll bridge or a free bridge, if the water over which the bridge is to be built is navigable, it is necessary to obtain a permit from the War Department. This permit is necessary because of the requirements of the above referred to general bridge act. In addition to obtaining the Federal consent it is sometimes the customary practice to also obtain state or county franchises or permits. The power to grant franchises for the construction of toll bridges wholly within one state, provided the water is not navigable in two states, lies with the state legislature unless it has been delegated by them to some subordinate body such as the Board of County Commissioners. The requirements of the Federal laws must also be complied with. Each state has adopted different and varied policies with regard to granting toll bridge franchises. Some states such as Florida have granted a number of franchises, each one of which contains radical different provisions and requirements; whereas other states such as Virginia have adopted a uniform policy, and in that state there is a general law which requires that for the construction of all toll bridges in the state a permit must be obtained from the highway commission and that the plans for the same must be approved by that body. This latter policy appears to be a more satisfactory method of procedure as it tends to remove the granting of franchises from the evils of politics. The earlier franchises granted by acts of Congress, of which there are some 150 in existence, were perpetual grants. Congress in 1926 and 1927 in general adopted the policy of granting authorization with a recapture clause so that after a 20-year period the bridge could be purchased under certain definite terms and conditions by public authorities. In the last session of Congress this 20-year period has been further reduced until a number of recent authorizations allow recapture after five years.

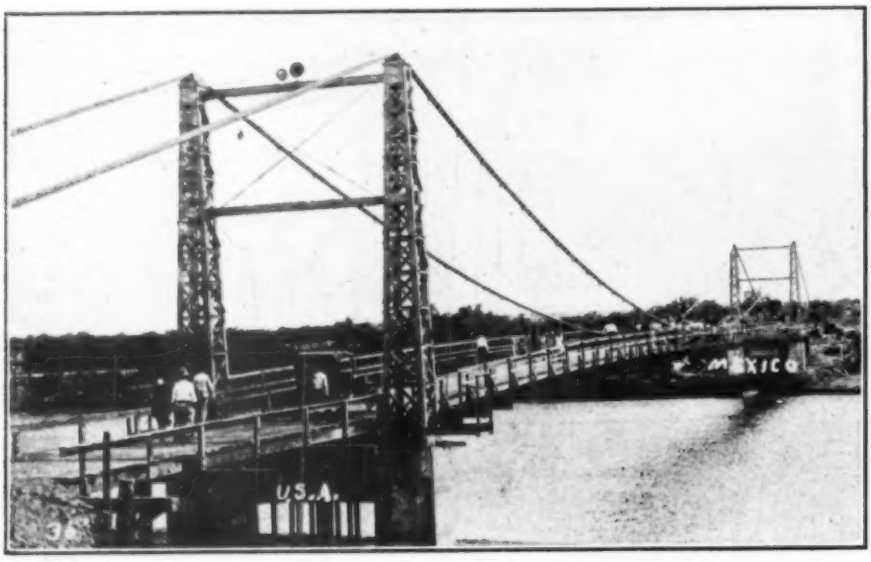

Fig. 2—Toll Bridge Over the Rio Grande at Hidalgo

Rates of Toll.—During the earlier period of toll bridge operation, in some cases the rates of toll were fixed by legislative action under the terms of the franchise which was granted, although more often the owners of the bridges fixed the tolls themselves and

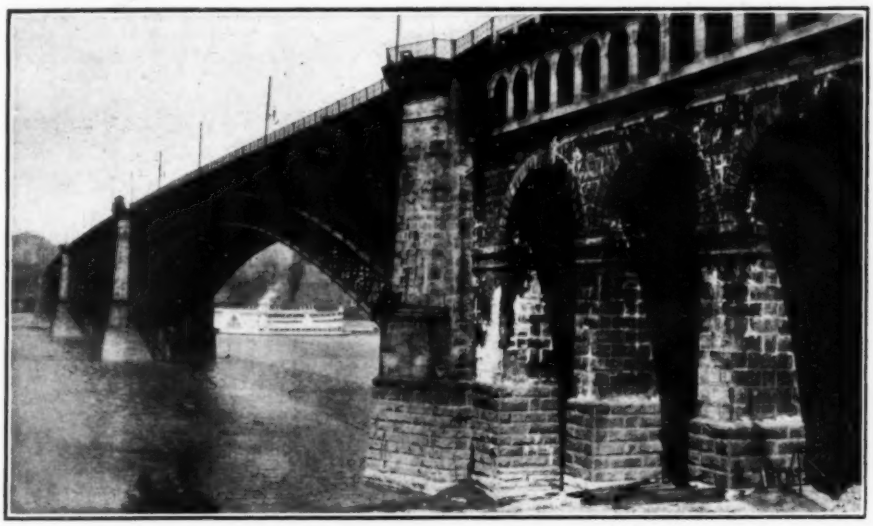

Fig. 4—Eads Toll Bridge Over the Mississippi River at St. Louis, Mo.

were governed by economic principles. Gradually the public utility thought has been extended to toll bridges until at the present time they are recognized to be such utilities and therefore are subject to regulation of rates as prescribed by Federal or State statute. The general Bridge Act of 1906 delegates to the Secretary of War and Chief of Engineers the power to regulate tolls on all bridges over navigable waters and the War Department has held a number of hearings under this authority. In many states, among them Pennsylvania, the state legislature has delegated to their public service commission the power to regulate tolls on all bridges within the state, and thus it may be seen that there is a direct conflict of federal and state jurisdiction.

The problem as to what is a fair and reasonable return to be allowed on toll bridges and whether this return should be based on original cost, reproduction cost or whether franchise value should be allowed are all more or less mooted questons.

Promotion of Project.—Private interests and capital have been responsible for the construction and financing of the greater number of the toll bridges in the United States. The promotion of a toll bridge project requires a long period of planning, and necessitates the expenditure of a considerable amount of funds. All the necessary franchises as required by state and federal statutes must be obtained and such permits as are necessary must be procured. In addition to this, traffic studies must be made from which the income that is anticipated will be received from the project can be predicted. It often happens that the authorization and franchises have been obtained for a project at a considerable cost, when upon the making of traffic studies it develops that the project is not sound from an economic viewpoint and cannot be financed. Thus it is that for each toll bridge project successfully financed and built, there are a large number which fail. There are in the United States a number of outstanding examples of toll bridge projects financed by private interests which have been serving the public; among such projects are the Eads Bridge at St. Louis across the Mississippi River, the Gandy Bridge in Florida across Tampa Bay, Bear Mountain Bridge in New York across the Hudson River, San Francisco Bay Bridge just completed across the bay at San Mateo. The bridge now being constructed across the Detroit River at Detroit, and across the Mississippi River at Vicksburg are likewise being financed and built by private interests.

The undertaking of toll bridge construction by public interests has grown very rapidly in the past few years. Toll bridges are often constructed and owned directly by the individual state, however, in the case of bridges between states it is necessary to set up an interstate political body such as the Port of New York Authority which is now engaged in constructing or has completed four interstate bridges, among which is the $85,000,000 toll bridge across the Hudson River. Another example of such an interstate body is the Delaware River Bridge Joint Commission, which has completed the $35,000,000 bridge across the Delaware River at Philadelphia. The State of North Carolina has constructed and is operating two toll bridges, one across the Chowan River at Edenton, and another across the Cape Fear River at Wilmington. The States of Alabama, Tennessee, Kentucky and Arkansas are all engaged in the construction of a series of toll bridge projects, Alabama having fifteen such projects under construction.

Methods of Financing.—The financing of toll bridge projects has been undertaken in a number of different manners. During the conditions existing in the financial market for the last few years first mortgage bonds on toll bridges could be readily sold and it was customary to issue such bonds to the extent of some 60 or 75 per cent of the cost of the property. At the present time, however, the trend of the market is demanding a participating security and it is probable that new toll bridges will be financed by the sale of securities of such a nature. The financing of toll bridges until recently has been conducted usually as an individual operation, that is, each bridge was financed as an individual unit. However, there is at the present time a tendency both with the states and with private interests to group toll bridges and put out securities of a holding company nature. Such consolidations or groupings are of a like nature to the development in the field of other utilities being joined together in holding companies. The State of Alabama recently sold $5,000,000 worth of toll bridge bonds put out by the Alabama State Bridge Corporation, which is a public body set up by State Legislature to construct, own and operate a series of fifteen toll bridges in that state.

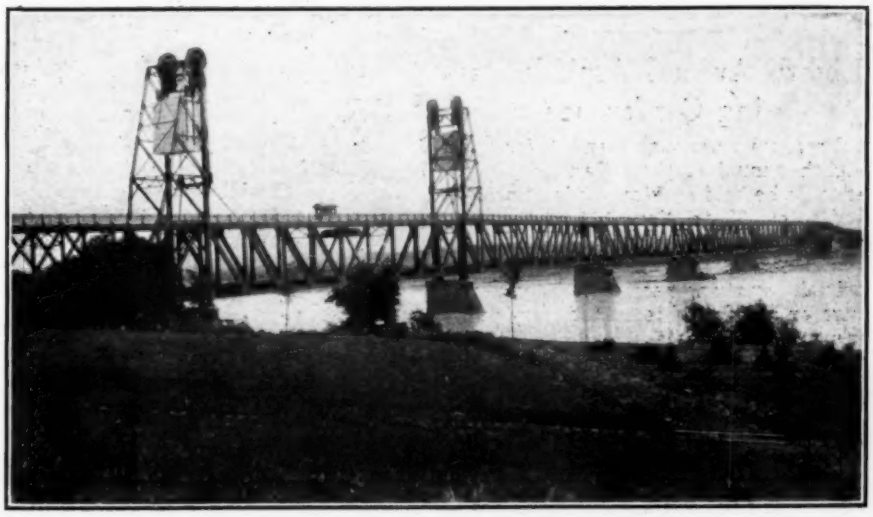

Fig. 5—Toll Bridge Over the Missouri River at Yankton

These bonds although issued by the state are not direct obligations of the state but are secured solely by the revenue to be derived from the operation of the series of toll bridges. These bonds are looked upon by the public, however, as more or less of a moral obligation of the state and have found favor among investors. In the past few years there have been placed on the market in excess of $227,000,000 worth of toll bridge securities, including both publicly and privately owned projects. In the total number of projects financed to date there have been some conspicuous failures, although the proportion of these failures is low in comparison to the total number of projects. This condition has been due to local enthusiasm for a bridge which has been allowed to overweigh sound engineering judgment and the consequence was that the bridge has been provided at the expense of the purchasers of the securities.

Wherever the state or federal government are able to construct a free bridge it is unquestionably advantageous to do so. However, there are certain sites, such as the crossing from Philadelphia to Camden over the Delaware where it would not appear justifiable to expend funds collected from general state or federal taxes for an expensive bridge which will be of the greatest value to the local people. A toll bridge at such a point places a tax directly upon the users rather than upon the public as a class and it therefore appears that the construction of toll bridges whether by state or private interests is advantageous, wherever it is not practical from an economic viewpoint to construct a free bridge. The granting of franchises and the financing of toll bridges is at present in the formative stage and it may be anticipated that in the next few years there will be considerable legislation enacted regarding toll bridges which will tend to safeguard the interests of the traveling public and to set up definite principles regarding the construction of toll bridges.

Eighth Annual Asphalt Paving Conference

Program announcements for the eighth annual Asphalt Paving Conference, to be held at West Baden Springs, Ind., Oct. 28 to Nov. 1 next, are indicative of an interesting and instructive meeting, with numerous highway officials and engineers presenting papers on timely subjects and participating in the oral discussions which will follow each paper presented. The conference will be under the auspices of the Asphalt Association, New York, N. Y., Leroy M. Law, of St. Louis, president, and J. E. Pennybacker, of New York, secretary and general manager, and the American Association of Asphalt Paving Technologists, W. J. Emmons, Ann Arbor, Mich., president, and C. A. Mullen, of Montreal, secretary.

One entire session will be devoted to the cooperative study of low-cost roads now being conducted jointly by the United States Bureau of Public Roads and the Asphalt Association.

The advance program of the conference follows:

MONDAY, OCTOBER 28TH

Registration

Committee Meetings

"Get Acquainted" Reception

Dancing

TUESDAY, OCTOBER 29TH

First Session, 10 A. M.

Chairman, LEROY M. LAW
President, The Asphalt Association

Opening Addresses—
Leroy M. Law, President, The Asphalt Association, St. Louis, Mo.
W. J. Emmons, President, American Association of Asphalt Paving Technologists, Ann Arbor, Mich.

Addresses of Welcome—
The Governor of Indiana or his representative.
John J. Brown, Director, Indiana State Highway Department, Indianapolis, Ind.

NEED OF LOW-COST FARM-SERVICE ROAD IMPROVEMENT

Address—"Low Cost Paved Farm-to-Market Roads—A National Economic Necessity," S. H. Thompson, President, American Farm Bureau Federation, Chicago, Ill.

Address—"Elimination of Traffic Congestion on Main Highways by Improvement of Farm-to-Market Roads," Ernest N. Smith, Executive Vice-President, American Automobile Association, Washington, D. C.

"Research a Factor in Solving the Low-Cost Road Problem," R. W. Crum, Director, Advisory Board on Highway Research, National Research Council, Washington, D. C.

TUESDAY, OCTOBER 29th

Second Session, 2 P. M.

Chairman, A. J. WEDEKING
Chairman, Indiana State Highway Commission

METHODS OF LOW-COST ROAD CONSTRUCTION

Co-operative Research and Standardization of Low-Cost Road Improvement

"Federal Government Participation," H. S. Fairbank, Chairman, Research Committee, U. S. Bureau Public Roads, Washington, D. C.

"Industry Participation," Prevost Hubbard, Chemical Engineer, The Asphalt Association, New York, N. Y.

"Progress in Field Studies," J. T. Pauls, Highway Engineer, Division of Tests, U. S. Bureau of Public Roads, Washington, D. C.

State Construction Progress

"Surface-Treated Sand-Clay Roads in the Southeast," B. P. McWhorter, Asphalt Engineer, State Highway Board of Georgia, Atlanta, Ga.

Discussion.
Opened by Gen. Charles C. Jamieson, U. S. A. retired, Jacksonville, Fla.

"Retread Construction in Indiana," A H. Hinkle, Superintendent of Maintenance, Indiana State Highway Commission, Indianapolis, Ind

Discussion.
Opened by J. S. Watkins, State Highway Engineer of Kentucky, Frankfort, Ky.

"Oiled Earth Roads in Illinois," D. O. Thomas, Superintendent of Highways, St. Clair County, Illinois.

Evening Entertainment, "County Fair and Carnival," Atrium of Hotel

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WEDNESDAY, OCTOBER 30th

Third Session, 9:30 A. M.

Chairman, R. M. SMITH
Deputy Minister, Ontario Department of Public Highways

State Construction Progress (Continued)

"Blotter Treatment of Gravel Roads in Minnesota," F. C. Lang, Testing Engineer, Minnesota State Highway Department," St. Paul, Minn.

"Surface-Treated Gravel and Macadam in Oregon," R. H. Baldock, Maintenance Engineer, Oregon State Highway Commission, Salem, Ore.

"Treatment of Subgrades with Asphaltic Oils," C. A. Hogentagler, Senior Highway Engineer, U. S. Bureau of Public Roads, Washington, D. C.

"Asphaltic Treatment of Earth Road Surfaces in Fresno County, California," Christ. P. Jensen, County Engineer of Fresno County, Fresno, Cal.

"Causes and Control of Damaging Frost Action in Shoulders and Sub-Grades," W. C. Buetow, Chief Engineer, Wisconsin State Highway Department, Madison, Wis.

"Black Base for City Pavements," J. H. Dingle, City Engineer, Charleston, S. C.

WEDNESDAY, OCTOBER 30th

Fourth Session, 2 P. M.

Chairman, W. J. EMMONS
President, Association of Asphalt Paving Technologists

JOINT MEETING WITH ASSOCIATION OF ASPHALT PAVING TECHNOLOGISTS

"Needed Improvements in Paving Plant Equipment and Methods," John W. Davitt, Chemical Engineer, Jersey City, N. J.

"Machine Finishing for Hot-Mixed Pavements in California," Charles S. Pope, Chief Construction Engineer, California State Highway Department, Sacramento, Cal.

"Resurfacing Concrete Roads with Asphalt Wearing Courses," W. H. Sharp, Engineer of Repairs, Connecticut State Highway Department, Hartford, Conn.

Discussion.
Opened by George W. Craig, Consulting Engineer, Chicago, Ill.

"Rough Texture Asphalt Pavements in Europe," F. J. Leduc, Chief, Municipal Materials Testing Laboratory, Montreal, Que., Canada.

Bridge Tea for Ladies, West Baden Springs Hotel, 3 P. M.

WEDNESDAY, OCTOBER 30th

7:30 P. M.—Technical Session

ASSOCIATION OF ASPHALT PAVING TECHNOLOGISTS

Concert Followed by Dancing

9 o'clock P. M.

West Baden Springs Hotel

THURSDAY, OCTOBER 31st

Fifth Session, 9 A. M.

Chairman to be selected

AIRPORT PAVING

"Standard Paving for Airports," R. H. Simpson, Chief Engineer, Department of Public Service, Columbus, O.

Discussion.

"Experimental Runway Construction at the Lambert-St. Louis Municipal Airport" (Illustrated with moving pictures), Mark R. Thompson, Engineer in Charge of Bituminous Pavements, Board of Public Service, St. Louis, Mo.

Discussion.

"Oiled Runways for Airports," John A. Herlihy, Chief Engineer, Transcontinental Air Transport, Inc., St. Louis, Mo.

Discussion.

Thursday Afternoon, October 31st

Inspection Trip Over Indiana State Highways

FRIDAY, NOVEMBER 1st

Golf Tournament

Street Cleaning Methods and Costs

Nearly $500,000,000 Being Expended Yearly by Towns and Cities

By E. P. FREDERICKS

FEW civic movements in recent years have assumed the proportions of the present agitation in favor of cleaner streets. Practically every community of 5,000 population and over, as well as many smaller towns, are keenly interested in the subject of improved street cleaning methods, nor is the movement confined to the United States alone. In Australia, Spain, Italy, Russia, England, France and the leading South American countries there is a widespread interest in the subject of clean streets and city engineers the world over are seeking better and more economical methods of keeping thoroughfares clean.

Clean-Up Week.—Within the past few months this country has witnessed an observance of "Clean-Up Week" in more communities than have ever before gone in for this sort of work in an organized way. It is estimated that more than 3,700 cities and towns made a determined effort this year to observe "Clean-Up Week" in a practical and thorough manner. A survey of the entire country shows that at one time or another in the course of the past two or three years more than 7,000 cities have periodically observed "Clean-Up Week." Chicago, up to the present time, seems to have carried off the honors for the most consistent work along these lines, and has developed this activity to such an extent that it has become a perfectly organized part of the civic betterment campaign and is showing some very real and substantial benefits to the whole city.

It has become increasingly apparent, however, that in order to obtain lasting results the work stimulated by these "Clean-Up Weeks" must be perpetuated beyond the few days set aside each year for this purpose. In this connection cities and towns might well adopt the phrase introduced by the United States Chamber of Commerce in the preparation of a pamphlet entitled "Clean Up Your City and Keep It Clean."

Just how general has become the movement for cleaner streets can be gauged by the constant reference to the subject in the editorial and news columns of papers all over the country. In a number of cities "Clean Streets" Clubs have been formed to work in cooperation with the local city authorities in an effort to solve the problem. On several occasions the women have organized voluntary street cleaning brigades, as in the case of Norfolk, Va., and elsewhere, to help out in the work of ridding the streets of litter and refuse.

In a number of cities both in this country and abroad a very satisfactory solution of the street cleaning problem has been found through the adoption of the vacuum street cleaning system. This method is the result of more than ten years of development of the same principle that is applied to the vacuum cleaner in the home.

Formerly, and even at the present time, in many communities, the only methods available for street cleaning were hand sweeping, the rotary brush (horse drawn or motor driven) and flushing. Despite the most scrupulous care and even with the adoption of all the above mentioned methods it was found that there still remained the fine dust menace which health authorities agree is one of the most potent disease breeders and carriers in any community.

The vacuum cleaner as now constructed for street work is a combination of the enclosed rotary brush and a powerful vacuum. This serves the double purpose of removing the large litter and refuse and at the same time sucks the dust and finer particles from the pavement and from the grooves and hollows.

Street Cleaning Expenditures.—Naturally, the question of cost enters largely into any comparative methods of street cleaning as there are few civic departments that can show such discouraging results for the amount expended than in the case of the street cleaning department that is hampered by antiquated equipment or inefficient methods.

In a survey of street cleaning costs made by the government in 1926 it was shown that in a group of 250 cities ranging in population from 30,000 to 500,000 and over, that the annual expenditure in this group of cities aggregated more than $167,000,000 for merely sweeping the streets. This did not take into account the expenditures for other sanitary activities such as incinerators, disposal plants, snow removal and numerous other items that are frequently made a part of street cleaning operation. From other authentic sources it is estimated that the entire country, including all towns and villages where little provision is made to clean the streets at all, spends more than $500,000,000 a year in an attempt to keep the streets reasonably clear from dust and dirt! Despite this enormous outlay there are few communities that can lay claim to having achieved the highest point of efficiency in this department of city administration.

In some cities a definite sum is expended for the prevention of street dust, and this is particularly true in the case of cities ranging in population from 100,000 to 300,000. Strangely enough, this special department of street cleaning work is receiving more attention in the smaller towns than it is in the larger cities, if the annual expenditures for this work are to be taken as a basis.

Mechanical Street Cleaning Equipment.—The cost of cleaning streets through such methods as hand sweeping and flushing is fairly well standardized and this does not vary greatly in cities of the same class. If anything, the cost under the old methods is increasing as reflected in a report from W. J. Galligan, Assistant Superintendent of Streets in Chicago, who says "Due to our immigration laws, restricting the class of labor best adapted for this service, there is a resultant growing scarcity of available men, which has gradually increased the rate of wage. Realizing, therefore, that cities would be forced to other and more efficient methods, Chicago has long experimented with mechanical street cleaning equipment."

That other cities are rapidly adopting the latest mechanical street sweeping equipment is reflected in a recent survey of 150 of the principal cities of the country, more than 54 per cent of which have adopted the best modern mechanical appliances as substitutes for hand labor. Nor is the movement in favor of more modern methods confined to the larger cities.

A committee on street maintenance of the American Society of Municipal Improvements spent many months in an investigation of the use of street cleaning equipment in cities of more than 5,000 population, and it was found that even in cities of smaller size the majority were gradually installing mechanical devices to supplant the older methods.

Of the various sections investigated it was found that New England cities are employing a larger percentage of hand sweepers than any other section of the country. The Middle West and Pacific Coast districts are, for the time being, leading in the adoption of the more modern methods. In the smaller communities all over the country the horse-drawn rotary brooms are still very generally used, particularly among the Eastern States but reports indicate that it is the intention of these municipalities to dispense with this type of equipment as fast as possible.

A survey of 1,000 municipalities of less than 5,000 population shows that about 20 per cent do not make any attempt at all to do street cleaning, while the rest average a more or less perfunctory service of this kind about twice a month. The explanation is that no definite street cleaning program has been generally provided for in the annual budget.

Street Cleaning Costs.—Cities like Fort Smith, Ark., report an average cost of 22 ct. per M square yards for cleaning the streets with mechanical devices as against the cost of more than $1.00 for hand sweeeping the same area. In Chicago it is reported that the cleaning cost with motor driven sweepers will average 23.7 ct. per M square yards and this is about the average

cost in the larger cities throughout the country. In smaller communities, like Norfolk, Va., Utica, N. Y., Miami, Fla., Kenosha, Wis., which are representative of such cities the country over the cost can be held to about 20 ct. per M square yards. The average, taken from a number of cities in the same class and size, shows that the cost of hand sweeping will be about $.406 per M. square yards.

The cost is also materially increased as traffic congestion grows and because the parked vehicle in cities and most towns slow up all methods of street cleaning. Washington, D. C., has overcome much of this handicap through the co-operation of the police department which prohibits parking in certain zones during stipulated hours, thus giving the street cleaners an opportunity to work unhampered. This same co-operation was extended to street cleaning departments in many cities during the recent "Clean-Up Weeks" and it would appear to be a system that could well be perpetuated throughout the year in all cities in order to enable street cleaners to pursue their work more satisfactorily.

New Van Camp Gravel Plant Features Many Departures in Design and Machinery

The Van Camp Sand & Gravel Co. of Cincinnati, O., has just put in operation one of the largest and most modern sand and gravel plants in the country. The plant is located near Morrow, O., in Warren County.

Plans for the erection of the plant were completed in February of this year when an order was placed for the largest part of the machinery with the Smith Engineering Works of Milwaukee. This included all of the necessary feeders, conveyors, crushers, washing screens, sand tanks and bin gates to handle a capacity of 3,000 tons per 10-hour day. At the same time, contract was let to the Gifford Wood Construction Co. for the erection of the concrete silo bins and the Dayton Structural Steel Co. sublet the steel work. The entire plant is of concrete and steel construction. These contracts, including the Telsmith machinery, electric motors, pumps, structural steel, etc., were handled by Milburn Machinery Co. of Columbus, who represents the Smith Engineering Works in Ohio territory. Charles G. Milburn of the latter company was also responsible for the installation of the machinery and the initial operation of the plant. All plans and work were completed according to schedule and the plant placed in active operation just prior to Aug. 1.

The pit consists of nearly 200 acres of good sand and gravel. Steam shovels are used to excavate the material and load it into 20-yd. standard gauge air-automatic dump cars. These discharge into a large plant receiving hopper built of concrete and steel.

Two Telsmith 30 in. by 5 ft. 6 in. self-contained Timken bearing plate feeders, each driven by separate motors, are located under the receiving hopper to give a steady flow of material to a 36-in. wide by 160-ft. long conveyor. This delivers the pit run to a 4-ft. wide by 12-ft. Telsmith rail bar grizzly with 3-in. openings. Material passing the grizzly drops direct to a 36-in. by 300-ft. main plant belt conveyor, which delivers to the top of the plant. Oversize from the grizzly goes direct into a Telsmith No. 13-A primary breaker. This sets directly over and discharges into the 36-in. by 300-ft. main plant conveyor.

The latter conveyor discharges into a 72-in. diameter by 23-ft. long Telsmith Hercules scalping screen, equipped throughout with 2¼-in. round perforations. All materials passed by the 2¼-in. holes goes directly into a Telsmith 60-in. diameter by 24-ft. long Hercules washing screen, where sand and three sizes of gravel are separated, each size going to a concrete silo bin.

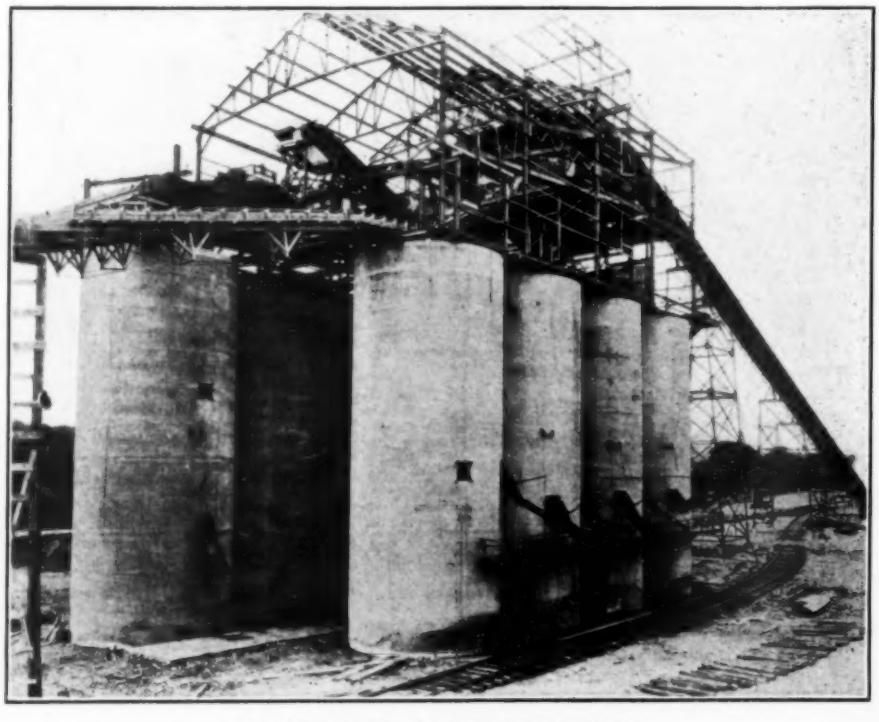
Oversize material from the 72-in. by 23-ft. Hercules scalper is chuted to a Telsmith No. 52 reduction crusher. Oversize from the 60-in. by 24-ft. Hercules washing screen is chuted to a 3-ft. Symons cone crusher. Both these crushers discharge onto a 30-in. belt conveyor, which in turn delivers to a second Telsmith 60-in. by 24-ft. Hercules stone screen, which is equipped to separate three sizes of crushed gravel. Any oversize from this latter screen goes back to the 3 ft. cone crusher. Stone dust and water from the stone screen are flumed to a Telsmith No. 7 sand settling tank, followed by a Telsmith 3-ft. by 6-ft. vibrating screen to dewater, separate and chute the recovered dust to the fine sand bin.

All sand and water from the 60-in. by 24-ft. Hercules gravel washing screen is flumed to two Jeffrey sand drags. These discharge onto two Telsmith 3 ft. by 6 ft. vibrating screens which separate the sand into a coarse and a medium grade, each grade going to a separate bin. The overflow from the sand drags is flumed to three Telsmith No. 8 automatic sand settling tanks for recovering the fine sand which also goes to a separate bin.

In all, nine concrete silo bins are used where the following materials are stored ready for shipment by either rail or truck: Pea gravel and ⅜-in. stone mixed; ⅜-in. washed and crushed gravel, 1¼-in. washed and crushed gravel, 1¼-in. washed gravel, 2-in. washed gravel, coarse sand, medium sand and fine sand. Each silo bin is 20 ft. inside diameter and 50 ft. high.

All screens, sand tanks, sand drags, vibrating screens, the No. 52 Telsmith reduction crusher and the 3-ft. cone crusher are located over the concrete bins on steel superstructure. All crushers and the main 36-in. by 310-ft. conveyor are equipped with Texrope drives. All screens are equipped with silent chain drives. All motors are of General Electric Co. make.

All of the Telsmith screens furnished for this plant are equipped with steel frames and Timken roller bearings. They are equipped with new Telsmith method of attaching and supporting screen sections and include extra heavy construction throughout. The two Telsmith crushers are equipped with steel frame and crown and special steel main



New Plant of Van Camp Sand & Gravel Co.

shaft and carry a two-year guarantee on these parts against breakage by tramp iron. All feeders, vibrating screens and conveyors are equipped with Timken roller bearings.

B. T. Van Camp is president of the Van Camp Sand & Gravel Co., John Sloan is vice-president, and John B. Campbell is secretary and treasurer. The directors include the above officers and John H. Liggett, Alfred A. Anderson and Philip Geier.

21,664 Miles of Road to Be Built This Year

A census of state highway departments completed recently by the American Road Builders' Association shows an estimated 21,664 miles of roads to be constructed this year in 42 states.

A questionnaire was sent to all states and figures received from all, except Connecticut and Nebraska, indicate $744,266,000 available for maintenance and construction this year. This sum includes highway funds apportioned by the federal government to the states, and funds raised by gasoline taxes, motor vehicle registration and various other methods.

The estimated county expenditures for 1929 are shown to be $405,150,000 in 40 states. This added to the state funds shows a grand total of $1,149,416,000, which is a conservative figure of the total money that will go into good roads during 1929 or the fiscal year 1929-30. The Bureau of Public Roads estimate is $1,315,000,000.

In hard surface building Iowa, which now has 1,900 miles, heads the list of states in mileage to be constructed and will pave 750 miles each year in 1929-30-31, making a total of 4,150 miles of paved road.

Kansas has a 1929 construction program with a total of 1,875 miles, which included 800 miles of grading, 1,000 miles of sand and gravel and 75 miles of hard surface.

New York, with 10,840 miles of all types of road, will add 700 miles this year and "700 plus" in 1930.

Ohio, with 6,660 hard surfaced and 3,837 miles of gravel roads, will add 300 miles this year.

Pennsylvania, with 7,485 miles hard surfaced in her total mileage of 12,756, will add 500 miles in 1929.

Texas, with 18,000 miles of all types, will add 800 miles this year and "probably the same" in 1930 and 1931.

West Virginia will add 360 miles of hard surface each year over the three-year period.

Wyoming will add to her present 39 miles of hard surfaced roads, 390 miles —of all types—in 1929 and 375 miles each in 1930-31.

Michigan, with 3,452 miles of all types, will build 560 miles this year and 500 each in 1930-31, making a total of 5,012 miles.

Alabama expects to build 1,100 miles of road in 1929.

Illinois this year will add 600 miles of hard surface to her present 7,525.

Kentucky will hard surface 382 miles of road this year and expects to exceed this program in both 1930 and 1931.

North Dakota, which now has only 15 miles of hard surfaced roads, will build 1,000 miles of all types annually in 1929-30-31.

Missouri will build 1,291 miles, all types, this year and follow next year with 917 miles more, giving that state a total of 2,876 miles hard surfaced.

Mississippi is the only state which has no funds nor estimate for construction this year. The state has matched federal aid with county bond issues in past years, but several proposed bills this year have failed, according to the state highway department.

The census further shows that in 22 states all construction is by contract, 23 states employ some day labor, when bids are too high, in emergencies, and on small projects, and convict labor is used on roads in Florida, Michigan and Virginia.

At least six states divided gas tax between the state and counties, Florida giving the counties four cents of her six-cent tax and Mississippi giving the counties three cents out of five. In the others, the states take the larger proportion.

Eight states hope to secure funds for road construction by bond issues in the near future. New Mexico and Maine expect to complete bond issues this year, Mississippi anticipates an issue in 1930, Maryland and Iowa in 1931, the latter for $100,000,000—Alabama and Georgia are desirous of issuing bonds with the latter state seeking $100,000,000.

Pavement Striping in California

From a modest beginning on curves as a safety measure the California state highway department is today maintaining traffic stripes on some 715 miles of pavement. Added to this is a considerable mileage of recently constructed pavement wherein the longitudinal joint serves as a permanent marking. The following notes in this work are taken from the 6th Biennial report of the Division of Highways of the California Department of Public Works:

"Pavements are marked into 10 ft. traffic lanes by 6 in. paint stripes, usually white, orange, or black in color, the latter being used exclusively on concrete pavements. While white excels in visibility, orange is occasionally used where black pavements are inclined to fatness, due to its greater effective period of coverage. The white and orange paints are lacquers applied under pressure with a hand propelled spray machine at the rate of 12 to 16 gal. per mile of stripe. For spraying operations this paint will require 1 gal. of thinner to every 5 gal. of lacquer. The black stripe is either "D" grade or petrolastic asphalt, which is occasionally covered with small sized gravel at the rate of 4 tons per mile. This rock covereage produces a raised stripe which is especially effective on wet nights when a strong glare is reflected from the film of water covering the pavement. In point of wear the asphalt is far superior to the lacquers, which require renewal every six to eight months. While a careful laboatory analysis is made of all paints purchased, the results are not always an accurate indication of their wear or coverage.

"While the multiple zoning of pavements is admittedly an aid in the control and regulation of traffic, much of its benefit can be lost through the careless disregard of its tenets by slow moving traffic usurping the inner or fast traffic lanes. Again, on multiple zone pavements, traffic peaks in either direction may require and should have the right to use all lanes not required by the opposing traffic. These however, are points requiring special regulation which will surely follow a better understanding of the traffic flow problem.

National Paving Brick Manufacturers Association to Meet in December

The 24th annual meeting of the National Paving Brick Manufacturers Association will be held December 4-5-6, 1929, at the Palmer House, Chicago, Ill.

The program for the last two days will include papers and discussions of the latest practices in the design and construction of streets and highways, particularly the vitrified brick type.

These sessions will be open to the general public and any one interested in street and highway development is invited to attend.

The program, now under preparation, will be presented by leading engineers and paving authorities. There will be discussions of such subjects as the resurfacing of old pavements with vitrified brick; the salvaging of old bricks in reconstruction projects; the proper use of bituminous fillers in vitrified brick pavements; efficient management of brick paving contracts; and regional highway planning for metropolitan areas.

There will be a banquet Thursday night, Dec. 5th, and business conferences will be held on the first day of the meeting.

W. A. Bonitz, President of the Crescent Brick Company, Pittsburgh, Pa., is president of the National Paving Brick Manufacturers Association; and George F. Schlesinger, 1245 National Press Bldg., Washington, D. C., is chief engineer and managing director.

Oiled Gravel Roads in Colorado

Methods and Costs for Three 1928 Jobs

By J. E. MALONEY
Assistant Engineer, Colorado State Highway Department, Denver, Colo.

SHORT stretches of road, in three widely separated sections of the state were oiled in 1928. A brief description of these three pieces of work may be of interest.

Vernon Canon Road.—This road is located about eight miles southwest of Denver; it is a part of the Victory Highway (U. S. 40), and is on the Denver Mountain Park Highway system. It carries part of the traffic from Denver to Idaho Springs and points west. The section oiled is at an average altitude of 6,100 ft. Grades range from 2 to 6 per cent. Rainfall for the year is 14 in.; for the months during which the work was done the rainfall was: July 1.75 in., August 1.40 in.

Temperature for the past six months has averaged as follows:

	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mean.	72	71	63	51	40	32
Min.	59	58	49	38	27	20

We have no accurate traffic count for any period beyond a few days observation, but we have estimated the traffic from our records on the main south Golden road.

The records we have indicate a traffic of 1,000 vehicles per day for the yearly average. Practically all the truck traffic to the Mountain Parks and Idaho Springs passes over this road. This road was graded, drained, and surfaced in 1923 as a federal aid project.

The surfacing was of crushed gravel 6 in. in depth; and 18 ft. in width, constructed in two courses. The bottom course was 4 in. thick, and was composed of stone which passed a 1½ in. screen with circular openings. The top course, which was 2 in. in depth, was of crushed material passing a ¾ in. screen with circular openings.

The section is 26 ft. wide, 18 ft. surfaced, with a 4 ft. shoulder on each side and a crown of 4½ in.

Five years of service had worn through the surfacing into the base course, leaving from 2 to 4 in. of well-compacted stone on a good sub-base. Some of the larger stones protruded, making the surface slightly rough.

In discussing the advisability of oiling this piece of road, the various methods in use were considered. It was decided not to scarify or disturb the existing surface, but to clean it of the loose dust, fill the major depressions (of which there were not many), and then to apply a surface treatment of about 1 gal. to the square yard, covering the oil with crushed stone ranging in size from about ¼ in. diameter to dust. This material consisted of the fine run of the crusher.

Forty-six thousand and five hundred gallons of oil, or 1.27 gal. per square yard were used.

This work was done by the Denver city highway department equipment and forces under the direction of F. J. Altvater, Superintendent.

Method of Work.—The road was worked in sections of about 1 mile in length and half the width of the road so that traffic was not interrupted.

The loose material was broomed to the sides. Crushed material was used to bring up a few places to a more even surface. Oil was applied by an oil distributor at the rate of ¾ gal. to the square yard for the first application, followed by another application to take up lean spots of about ½ gal. to the square yard. Then the crushed fine material was spread by hand, using shovels, to about 1 in. in thickness.

This road has now been in service for six months. A recent examination shows a few shallow ruts, and several small potholes cut through the oiled top. These can be readily repaired. Openings cut in the road show an oiled top which has an average thickness of 1 in.

The rutting and some of the chuck holes are undoubtedly caused by the chains on the vehicles as well as by the tendency to travel in one track particularly after snow storms.

It has been suggested by Mr. Altvater, that only clean stone particles from ½ in. to a No. 10 mesh size be used for the top covering, and I believe this would be an improvement.

The method for this type would be: Clean the surface of all dust; bring up to desired section; spread top material along shoulders on each side, so that it can be picked and spread over the oil with blade; apply oil; spread top stone with blade until satisfactorily placed.

The total cost of this 3½ mile project was:

Crushed stone	$1,466.50
Road oil	3,255.00
Labor	1,726.30
Total	$6,447.80

The cost per mile was $1,842.20 and to this should be added about $100 per mile for use of the equipment. Oil cost about 6.13 ct. per gallon at Denver; labor was $5.00 per day of 8 hours, and the stone cost $2.00 per ton. There was a 3½ mile haul for the stone.

In the past six months there has been very little maintenance on this piece of road. Three trips of a blade grader pulling some loose stone from the shoulders to the road have been made, the cost being not more than $20 per mile for the six months.

San Luis Valley Project.—This project is on the road between Alamosa and Antonito in the southern section of the state. It is on the federal aid system on the road to Cumbres Pass. The section oiled is at an average elevation of 7,700 ft. The country is flat and grades are light. The length of this project is 5.3 miles.

Rainfall for the year is 6.30 in.; the observations being for a point six miles east of the road at Manassa. For the months of August and September, 1928, when the work was being done, there was 1.61 in. precipitation.

Mean and Minimum Temperatures

	Jan.	Feb.	Mar.	Apr.	May	June
Mean.	24.4	24.8	35.1	40.4	51.0	56.4
Min.	—4	—4	3	5	27	32
	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mean.	61.6	58.4	58.5	45.8	30.0	17.2
Min.	35	36	26	14	—3	—14

Traffic has been estimated to be 500 vehicles per day.

This stretch of road was graded, drained and surfaced with crushed gravel under contract as a federal aid project in 1928. This work was completed in July, and the oiling and surface mixing was done by state forces soon thereafter.

The oil treatment and mixing was under the direct supervision of W. J. Walsh, Resident Engineer. The absence of satisfactory binder led us to decide upon oiling this surface and thus get a practical demonstration of its desirability under these conditions.

The surfacing was 6 in. in depth in two courses of 3 in. each. The bottom course was compacted as much as possible by rolling and wetting while the top course was left loose.

For both courses all stone passed a 1-in. screen with circular openings, the sieve analysis being as follows:

Bottom Course

	Per Cent
Passing 1 in.	100
Passing ½ in.	70
Passing ⅛ in.	38

Top Course

	Per Cent
Passing 1 in.	100
Passing ½ in.	70
Passing No. 10	30

The top course material was mixed with the oil. Work was started in August and finished in September, being interrupted by several rain storms.

Through the kindness of Mr. Davidson the Colorado State Highway Department was materially assisted by Mr. Cash who has been in charge of the work in New Mexico. The width of surfacing is 18 ft. with a crown of 4½ in. The oil was applied from an Etnyre distributor of 950 gal. capacity. The distributor was followed by the discs and by the blade graders which turned the stone and oil from one side to the other until the material was thoroughly mixed.

Road oil from three different companies was used upon this job; as far as possible these oils were applied to separate pieces of road, so that any difference in behavior might be noted. The road parallels the railroad, so delivery of the oil in cars was convenient. I can say, that up to date, no difference has been observed between the oils which were used.

The equipment used was:

1 Etnyre distributor
1 boiler for heating (Case machine)
3 tractors 30's

3 blades
1 light blade (6-ft.)
1 Fordson
1 disc

The crew was composed of:

1 foreman
5 truck and tractor operators
1 distributor operator
4 blade men
1 fireman
1 watchman
3 laborers picking large stones off the road

The cost was as follows:

Road oil at 8 cents per gallon f.o.b.	$ 6,482.00
Coal for heating oil	96.14
Small tools, pipe fittings and repairs	78.81
Gas and oil for equipment	666.71
Labor	1,926.31
Rental of equipment	1,200.00
	$10,449.97

The cost per mile was $1,972.65 for 5.3 miles. This cost can, I believe, be reduced as this first piece involved the breaking in of a crew and was for a short stretch of road. This road is in very good condition at present. Some cracks have appeared and slight damage by rutting from narrow-tired wagons has been noted.

Northern Colorado Section.—Fourteen miles of the important federal aid road from Denver to Cheyenne, via Greeley, was selected for oiling. This section is from the Wyoming state line south to a point just north of Nunn. Grading and drainage were completed in 1926. The contractor for the surfacing of this section had completed part of his work, and the oiling was started on the completed portion at the south end of the fourteen mile stretch under the supervision of A. B. Collins, District Engineer.

The surfaced width is 18 ft. with a crown of 4½ in. The surfacing stone was in general of the following sizes:

Passing 1 in. screen 100 per cent

Passing ½ in. screen 55 to 70 per cent

Passing ⅛ in. screen 35 to 60 per cent

Passing 100 mesh 2 to 9 per cent.

The average daily traffic is estimated at 800 vehicles per day. The elevation of this project varied from 5,100 ft. at the south end to 6,100 ft. at the state line.

Rainfall and temperature are from records taken at Grover about 33 miles east of the road.

Mean and Minimum Temperatures

	Jan.	Feb.	Mar.	Apr.	May	June
Mean.	31.4	30.4	37.6	43.0	56.2	56.8
Min.	—16	—5	—1	2	30	37
	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mean.	69.3	70.2	.....	.....	37.0	26.1
Min.	44	44	.....	.....	10	—7

Rainfall was about 9 in. at Grover. It may be noted that while the temperature range is about the same as at Greeley, which is 30 miles south of the road section, the rainfall at Greeley was 16 in. for the year. During the progress of the work 1.56 in. of rain fell at Greeley.

On the completion of the oiling in the San Luis Valley, the oil distributor and disc were sent to this northern work, a distance of 340 miles. The balance of the equipment needed was rented from Weld county. Two supply tanks mounted on trucks were put into use to haul the oil from the nearest railroad siding, which was seven miles distant from the project.

Oiling began on Oct. 10 and work was stopped Nov. 11 on account of cold weather after 3.7 miles had been completed. The actual working time was 22 days. Lost time on account of weather amounted to 11 days. Oil used amounted to 62,515 gal. This was at the rate of 1.6 gal. per square yard. On account of the cold weather there was considerable balling of the oil and finer particles. This caused extra work in mixing in order to break up the oil-balls.

Costs.—It finally became so cold that when we had used all the oil on hand, further work was postponed until spring. The costs on this project were as follows:

Road oil at 6.15 ct. per gallon	$3,844.67
Rent on tractors, trucks, Fordson	1,790.00
Rent on boiler	130.00
Labor	2,108.90
Demurrage	19.00
Kerosene, gas, signs, etc.	188.29
Superintendent's expenses and auto expenses	1,077.14
Rental value of state owned equipment	600.00
	$9,758.00

This is at the rate of $2,637.30 per mile. This cost is high, and probably can be reduced; however, work of this kind in cold weather will run several hundred dollars per mile higher than that done during warmer seasons of the year. The two supply tanks with drivers, which were necessary, also added to the cost.

The present condition of this piece is excellent and gives promise of good service.

Oils.—The oil was all purchased by open bidding f.o.b. at the railroad siding nearest the work. We used California and Wyoming oil. This oil was furnished under the following specifications for all three of our projects. The designation "fuel oil" is in accordance with the usage of the oil companies.

Fuel Oil: Fuel oil used as a binding medium shall be the product of an asphaltic base oil. It shall be either a naturally homogenous oil or a homogeneous residue from oil. It shall not have been distilled at a temperature high enough to injure the oil by burning or to produce flecks of carbonaceous matter. It shall contain not more than one-half of one per cent (0.5%) wax. Medium fuel oil shall contain not less than sixty per cent (60%) nor more than seventy per cent (70%) of asphaltic residue having a penetration of eighty (80) at a temperature of seventy-seven degrees (77°) Fahrenheit.

The medium fuel oil shall meet the following requirements:

Flash Point: The flash point by the Pensky-Martens closed tester method shall not be lower than 175° F.

Viscosity: Medium fuel oil shall have a specific viscosity (Engler) at 122° F., of not less than 25 nor more than 45.

Water and Sediment: Water and sediment combined shall not exceed two per cent (2%).

Test Methods: All tests of fuel oil, except the viscosity and asphalt determinations, shall be made in accordance with the latest adopted standards of the American Society for Testing Materials applicable thereto.

Viscosity: Specific viscosity (Engler) shall be determined in a 50 cubic centimeter sample in the manner described in the United States Department of Agricultural Bulletin No. 1216, page 59. The determination of viscosity may also be made at the option of the producer, in accordance with the standard viscosity test of the American Society for Testing Materials, serial designation D 88-26, using the Saybolt-Furol viscosimeter at a temperature of 122° F., in which case, the Saybolt-Furol time shall be not less than ninety (90) nor more than one hundred sixty (160) seconds for the medium fuel oil.

Asphalt Content: Asphalt content shall be determined by open evaporation using the tentative standard method of the American Society for Testing Materials, serial designation D 243-26 T.

Test report: A test report shall be furnished in quadruplicate by the vendor at the time of shipment of each car load showing quantity, gravity, viscosity, and asphalt content of the fuel oil contained in the car. These test reports shall be furnished to the State Highway Department at Denver, Colorado.

Basis of measurement: The unit of measurement of fuel oil shall be a barrel consisting of forty-two (42) U. S. gallons of oil at a temperature of 60° F.

Conclusion.—In general, I can say that our small experimental work in oiled surfacing has been satisfactory, and that the work is to be continued this year.

Acknowledgment.—The foregoing is a paper presented the 1929 Highway Conference at the University of Colorado.

Sao Paulo, Brazil, to Spend Nearly $2,500,000 on Roads in 1929.—Statistics recently published as to the 1929 budgets of the municipalities of the state have appropriated about $830,000 for roads, an average of 4½ per cent of the total appropriations for all purposes. The appropriation for roads in some municipalities was as high as 40 per cent of their appropriations and in the case of 13 municipalities exceeded 20 per cent. Moreover, the State Government has appropriated for roads during the current year more than $1,500,000. In addition there is considerable private expenditure such as that on the new concrete road from the city of Sao Paulo to Santo Amaro.

Oiled Gravel Roads in New Mexico

Methods, Equipment, Costs and Benefits

By E. B. BAIL

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THE writer feels that there is no question in the minds of those present at this conference as to the benefits to be derived from the surface treatment of gravel and crushed-rock roads. The relative value of these benefits will, of course, vary in different states and in different sections of the same state. It is the purpose of this paper to describe briefly the conditions leading to the adoption of this method in New Mexico, to set forth the procedure followed and the costs involved, and to indicate the benefits which have been or are expected to be derived.

Conditions Leading to Adoption of Oil Treatment.—New Mexico has a highway system of 5,300 miles. Of this amount the seven per cent federal aid roads amount to approximately 3,300 miles and state roads make up the remaining 2,000 miles.

It is estimated that 75 per cent of the traffic, including all truck and bus traffic, is concentrated on some 2,000 miles of the system. Including rental of equipment, there is an annual maintenance charge of $300 per mile on this portion of the New Mexico highway system.

Three hundred dollars per mile is not an excessive maintenance charge if by spending this amount our road surfaces could be maintained in first-class shape so that driving over them would be a pleasure and not an ordeal to be dreaded and avoided if possible. New Mexico has much to offer the tourist in the way of localities of historical interest as well as scenic beauty, and insofar as we fail to provide adequate access to these points of interest, by just so much do we cut down the revenues to be derived from these visitors. Hence in more than one sense, the building and maintaining of adequate roads is the most important business in New Mexico.

We have tried to make our crushed gravel and rock surfaces adaptable for dry weather maintenance by reducing the maximum size of stone from 1½ in. to 1 in. and in some cases to ¾ in. and increasing the percentage of material passing the quarter-inch screen to as much as 65 per cent. By constant dragging surfaces of this type can be maintained in better condition than those in which material is used having maximum stone of 1½ in. and over. In spite of all that can be done these surfaces go to pieces under the stress of months of dry, windy weather even though they carry only a moderately heavy traffic. The press of our state is alert to enlarge on tourists' complaints and the general impression a visitor gains after reading an Albuquerque paper is that the New Mexico highway department is singularly lacking in rudimentary intelligence. The writer is not prepared to state that this constant criticism is not good for us, but he voices the sentiment of the department when he ventures to believe that a bouquet now and then along with the brickbats would do us no harm.

To summarize briefly our expenditure of $300 per mile for maintenance does not produce satisfactory road surfaces.

The most disheartening feature of our experience in attempting to maintain crushed rock and gravel surfaces is the steady loss of material. In the cloud of dust behind every car you can see the dollars floating. The writer has often speculated as to just how much it cost the State of New Mexico to dust-coat the 284,000 tourist cars which passed through the state in 1928. The rate at which our surfacing is being worn away is not known but one road has lost 5 in. in three years and another has lost 4 in. in 3½ years. There is a short section of caliche-gravel surfacing in the Pecos Valley where the ground water level is close to the surface, which has stood up remarkably under fairly heavy traffic. This is very exceptional, however, and it may be stated that our annual loss of surfacing material is approximately one inch of compacted thickness.

These, then, are the conditions with which we must deal: (1) our maintenance costs are high for our scanty population and our maintenance does not give us satisfactory roads; (2) we are steadily losing our principal in the annual loss of surfacing. The very methods we use in maintenance tend to increase this loss.

Richer states can vote huge bond issues and in an intensive construction campaign extending over a relatively short term of years are able to lift themselves out of the mud and dust with high-type pavements. New Mexico is not financially able to do this. A cheaper type must be sought—one which, even though it may not lower maintenance costs, will at least preserve material and thus conserve the principal.

As far as New Mexico is concerned any method proposed for the accomplishment of the purposes outlined above must be reasonably cheap and sufficiently positive in results to ensure that public opinion will support the extension of its application.

Surface treatment of the roadway with medium asphaltic oils closely meets the above mentioned essential requirements.

The Methods.—At the time the New Mexico Highway Commission investigated the turnover or mixed-in-place method in California, a study was made of the equipment in use. This served as the basis for the selection of equipment a year later in New Mexico. California used a mixed outfit of one-man machines and tractor-drawn graders. All machines were low speed, but some were faster than others. It was noticed that the faster moving machines gave the material a much more pronounced roll than the slower ones. It was our belief that the more pronounced the roll or moldboard action, the better and quicker would be the mixing. With this idea in mind, one man graders powered by Caterpillar tractors of what is commonly called the 2-ton size have been adopted. These machines are fast, and can make four miles per hour in high gear. They are reasonably economical in operation and upkeep has not been excessive.

We found the California men using one disc-harrow, and were so favorably impressed with the utility of this machine that we adopted it and added another. These machines are very effective. They are drawn by 2-ton Caterpillar type tractors.

In California, when the mixing was complete, a 10-ton tractor, drawing a 10-ft. blade grader, was used to make the final spread. We did not have such equipment available and used our one-man machines. They did this work very well. It is probable that the heavier, tractor-drawn graders have a packing effect not secured by the one-man machines, but we do not feel that the added benefits are sufficient to justify the greater cost.

Until the surface has compacted sufficiently to hold up, we keep a light, 6-ft. blade on the finished roadway to take out traffic ruts. A rubber-tired Fordson tractor which did not fit in very well on maintenance was available and it proved to be amply strong for this work.

For heating the oil we have used a 60-h.p. steam tractor. This piece of equipment was acquired several years ago for use with a crushing plant. The boiler is in good condition and it is of ample capacity. This machine is geared to be self-propelling, but on short moves it is towed by the Caterpillar tractors. Water supply for this

boiler is furnished by a tank mounted on a 4-wheel trailer which is drawn by the service truck. A second-hand steam pump was picked up for use in the Rio Grande Valley where water can be reached with a short length of pipe and a sand point.

For servicing the above outfit, we use a 1½-ton truck. The driver of this truck is fairly busy during the day but he is not too hard pressed to work after hours and service the tractors so that everything will be in readiness for the next day.

The Equipment and Labor.—In addition to the above we furnish a roadster with pick-up body for the superintendent and one for the time-keeper who is also sampler and assistant to the superintendent.

To summarize, the following equipment is used:

2—2-ton tractors
4—one-man graders (8-ft.) with 2-ton tractor
2—disc-harrows
1—Fordson tractor
1—steam tractor
1—6-ft. grader
1—service truck
2—Ford or Cherolet roadsters with pick-up bodies
1—water tank on trailer

Man power for this outfit consists of:

4—men on one-man machines
2—men on disc-harrows
1—man on Fordson tractor
1—man on 6-ft. grader
1—man on steam tractor
1—man on service truck

10 men
1 superintendent
1 timekeeper

At new prices the above equipment will cost approximately $22,000.

The oil distributor which we have been using is the property of the Gilmore Oil Co. This company furnishes the operators, and charges us a fixed price per gallon of oil delivered on the road. The tank is of 1,259-gal. capacity mounted on a 5-ton Pierce Arrow chassis. This unit has proven entirely satisfactory.

This outfit has oiled, mixed, and spread a little more than a mile in one day in hot weather. This is a maximum. In 6½ months its average rate of output has been 11 miles per month. Not a little of this time was consumed in moving, one move by rail of over 300 miles having been made, and another of more than 250 with several shorter moves of 75 miles or more.

Costs.—Most of our work this past season was done on widths of 18 ft. having a thickness of loose, untreated material which averaged 3 in. Treatment of this width and thickness has cost on the average of $1,500 per mile for oil and mixing. This is for average working conditions.

A combination of rain and cold weather increases costs. We treated a 10½-mile section between Sept. 25 and Oct. 23. This job was at an altitude of about 6,500 ft. The loose untreated thickness was 4 in. with 90 per cent of the material passing the ¼-in. screen and a little more than 70 per cent passing the 10-mesh screen. Several rains came at this time, and each rain was followed by a temperature so low that ice formed. In the middle of the day it was warmer but an enormous amount of mixing was required throughout the job. This section required 1.71 gal. of oil per square yard and cost $1,940 per mile. The oil cost $2.61 per barrel at siding.

The last job of the season was finished in mid-December. It was at an altitude of 3,400 ft. and in the southern part of the state. Here we had more rain than we needed, but temperatures were higher, and oil was 17 ct. a barrel cheaper, and this section was completed for $1,810 per mile although the loose untreated thickness was 4 in. After mixing, the treated surface was spread to a width of 20 ft. It is our intention to make all future treatments 20 ft. wide. On an 18-ft. width traffic tends to wear the edges and the extra foot on each side seems to help this situation.

Eighty-four per cent of the roads treated last season required the placing of new material in advance of oiling. On some roads the original surfacing had worn so thin that scarification would have left nothing on which the oiled mat could be supported. Another road had ample thickness to allow for scarifying but the material itself was not suitable for treatment. In another case there was an ample thickness of surfacing, but this particular material had not really compacted in the five years it had been down. The shoulders material is a silt of low binding value and by working some of this into the surface we had been able to build up a crust of perhaps two inches in thickness which would hold the light travel on this section for perhaps a month after a rain. We caught this road immediately after our summer rains while this crust was still intact over most of the job and placed and treated four inches of new material.

Benefits Derived.—It can be stated that the greatest benefit we have had from the oil treatment of our road surfaces cannot be directly measured by the engineer's yardstick. The which is the most important of all the imponderables with which the highway engineer must deal and that is the immediately favorable reaction of the public. Popular approval of highway policies is seldom, if ever, based on sound economic grounds. So, in those rare instances where we have both public support and economic justification, we are doubly fortunate.

Coming now to those features to which we may apply the yardsick of dollars and cents, we may properly inquire as to the effect of oil treatment on our two ancient enemies—maintenance cost and loss of material. The writer estimates that where oil treatment has been applied to reasonably acceptable aggregates on a well drained and compacted foundation the average annual cost of maintenance should not exceed $125 per mile for New Mexico roads. On one road the maintenance cost may be double this amount, but this road meets none of the drainage and foundation requirements mentioned above, in fact, as far as oil treatment is concerned, it is the best possible example of what a road should not be.

Other treated sections comply reasonably well with the requirements for drainage and sound foundations, and for those we have the following cost figures to report:

A section 11½ miles long, carrying up to 800 cars per day of which 12 per cent consists of heavy buses and trucks, has cost a little less than $150 for the entire section for a period of five months. It may be interesting to note that automobile traffic was not responsible for this cost. The money expended was for patching the edges of the treatment where it had been chewed up by the narrow-tired wagons which are used by the natives. It should be stated that these narrow-tired wagons are the worst enemy to good results which we have yet encountered. During the mixing process these wagons use the road together with the automobile traffic. The droppings from horses become incorporated in the mix and eventually are responsible for most of the pot holes which develop in the surface. These wagons do their worst damage immediately after the mix has been spread. Drivers invariably keep one wheel on the edge of the treated surface. The narrow tires have no compacting effect whatever, but cut through the mix and into the subgrade below, chewing up the treated material and mixing it with loose foundation maeerial until the mix is so lean that it is quite impossible to compact it.

On a section 16 miles long, which carries about 500 cars per day, we have spent $50 during a period of three months.

It is not contended that the above costs are representative of what may be expected but they are far below what we would have had to spend on a new gravel surface in the same time. Thus far none of these roads have given indication of needing more than a proportional sum for some time to come.

We shall be able to tell you more about the matter of maintenance costs next year. We hope to be able to tell you about our costs on a section of this type of road which carries a daily year-round traffic in excess of one thousand cars per day. This section was completed a little more than a month ago, and as yet has no maintenance history.

It should be noted that the above mentioned estimated cost of $125 per mile per year is for top maintenance only.

Saving Due to Eliminating Loss of Material.—On this item we expect to make our most substantial saving. We believe our figures are conservative, as they are based on the minimum amount

of gravel necessary to bring our average surface thickness up to federal aid standards. When we speak of "average surface" we refer especially to our older roads which were constructed during the period 1920-1925. These roads have worn down to such an extent that we are going to have to do something to them right away.

We estimate the minimum requirement to bring these roads up to standard to be 1,200 cu. yd. per mile. This is the equivalent of 4 in. of loose material over a width of 18 ft. which will compact to 3.2 in. Assuming a conservative rate of wear of 0.8 in. per year, this surface will have to be completely renewed at the end of a 4-year period.

We estimate that on the average this material will cost $2.50 per cubic yard in place on the road, or $3,000 per mile. Based on this cost the annual loss of material is $750 per mile, and it is expected that our oil-treated roads will save this amount annually on every mile which is treated. Maintenance costs may increase and even equal our present replacement costs, but, we fully expect to retain and conserve every cubic yard of material after it has been properly mixed.

The Road Oils.—It seems pertinent to discuss briefly the oils we have used during the past season.

Naturally, we began by using an oil which by personal observation was known to have given satisfaction on the California work with which we were familiar. More of this oil than of any other has been used and in no case has it failed to give satisfaction. This oil costs $1 per 42-gal. barrel f. o. b. California points. The same company has also furnished us another oil which costs 90 ct. per barrel. We have used several cars of this oil and at present are dividing the business on our pre-mix jobs between this company and a competitor whose oil costs 90 ct. per barrel.

In southeastern New Mexico, early in 1928, a well was brought in from which the crude showed an asphalt content of 48 per cent and a paraffin content of 3 per cent. A local refinery cut the paraffin to six-tenths of one per cent and raised the asphalt to 75 per cent, 100 penetration. A carload of this oil was used on a pre-mix job at Roswell and it appears to be as satisfactory as the California oils.

Laboratory tests show no pronounced superiority of one oil over another and thus far we have not been able to say that a section of road treated with one oil is any better or worse than the adjoining section which was treated with competitive oil. Perhaps a year from now we shall have more information about this.

The Aggregates.—We have been conservative in the matter of the aggregates treated. In California we saw siliccous aggregates mixed with oil and made into an excellent surface, so we have stuck to the siliceous aggregates. We have avoided crushed limestones and have shunned caliche as though it were a plague. We may have missed something but we have not lost anything. We have treated aggregate having as low as 35 per cent through the 10-mesh screen and we have treated material carrying up to 85 per cent through the 10-mesh screen and to date there have been no failures insofar as the mix is concerned.

It is obvious that from the very nature of the material which has been treated we could not have a uniform mix in any of our turnover type surfaces. The fines vary from foot to foot and we try to use enough oil to take care of the excess fines and trust that the excess of oil at some other point will not be sufficient to cause bleeding.

We have some roads surfaced with crushed limestone and we would like to have the opinion of engineers from other states relative to the advisability of scarifying and oiling this material. Ninety per cent of it will pass a 1-in. ring and it is bound by crusher fines.

In the eastern and southeastern sections of our state there are more than 500 miles of road surfaced with caliche and caliche-coated gravel. These roads are quite satisfactory but are terribly dusty in dry weather and surface wear is rapid when traffic is heavy. We would like to treat these roads with oil but are not certain as to how to go about it. Sand and gravel can be brought by rail to many of these jobs but this is expensive. We will be greatly interested to hear of the successful treatment of caliche.

Pre-Mix Method.—In closing this paper, brief mention will be made of our experiments with the pre-mix method.

We have 41 miles of this type under contract. We have been separating material at the 8-mesh sizes and recombining in proportions that will take care of the run of the pit with as little waste as possible. Operations can be carried on by this method when it would not be practical to use the turn-over process. A much closer control of the mix is obtained. In order to carry on this type of work economically a dryer should be included in the equipment. The necessary equipment is cumbersome, expensive and requires a large tonnage to justify its use. Whether the close control of mix will give a sufficiently superior product to warrant further employment of this method is something which we hope to be able to tell you next year.

The writer wishes to acknowledge the indebtedness of the New Mexico Highway Department to District Engineer J. W. Johnson and Construction Engineer Bright of the U. S. Bureau of Public Roads for the first definite and practical information relative to the effectiveness of oiled gravel roads and the possible application of this type of construction to New Mexico problems.

Acknowledgment.—The foregoing is a paper presented at the 1929 Highway Conference at the University of Colorado.

Housing and Storage for Highway Maintenance

In the extensive territory administered by the Maintenance Division of the State Highway Department of California, many locations, while desirable as working centers, offered little or no accomodations for labor or storage of equipment. Quickly realizing the necessity of both, the state initiated a policy of acquiring maintenance sites, either by lease or by purchase, and constructing thereon the shelters needed. An interesting summary of this policy is given as follows in the 6th Biennial report (biennium ending July 30, 1928) of the Division of Highways of the California Department of Public Works:

To date some 194 sites have been acquired, 61 by lease and 133 by purchase or by special use permit, the total investment, exclusive of shops and office buildings, amounting to $633,700. While the investment is considerable, it usually does not exceed the rental charge for these accommodations capitalized at 5 per cent, and in addition assures a higher type of labor and protection for equipment.

The site, ordinarily one acre in area, is fenced and a plot reserved about the cottage which is planted to lawn, trees and shrubbery. The standard foreman's cottage, consisting of four rooms, bath and basement, cost between $3,000 and $3,500. Its rental is based on a yearly depreciation of four per cent, plus upkeep. Where the number of laborers justifies, a standard bunkhouse, consisting of living room, kitchen, sleeping quarters, toilet and shower, is constructed at a cost of approximately $2,000, no rental being charged for its use.

Standard truck sheds, ranging in size from 60 ft. to 100 ft. in length by 30 ft. in width, are constructed of galvanized iron sheeting over a substantial wooden framework, with concrete floors, wash racks, pits, sink, toilet and lights, at a cost of $25 per lineal foot.

Maintenance stations, disbursing daily 50 gal. or more of gasoline, are equipped with a 5-gal. gas pump and standard oil shed, which not only reduces hazard but effects a saving in labor and supplies as well.

It is hoped to eventually secure and improve maintenance sites at all important working centers, as the increased morale of the men, protection afforded equipment, and the accessibility of both in times of emergency amply justify the continuance of this policy.

Roadside Activities on California Highways

Removal of Fire Hazards—Control of Weeds—Roadside Treatments

THE development and improvement of the traveled way has gradually directed public attention has gradually sity of adopting a similar program on the remaining area of the highway right-of-way. In California this improvement both for esthetic and economic reasons has to date, in addition to tree planting, included the removal of grass and brush growths constituting fire hazards, the eradication of obnoxious weeds, together with a comparatively recent program designed to insure and improve the natural beauties of the roads by the preservation of wild ferns, shrubbery, and tree growths. The activities of the California Highway Department along these lines are supervised by the arboriculturist of the department. They are outlined in the sixth biennial report (for biennium ending June 30, 1928) of the Division of Highways.

Fire Hazards.—The elimination of roadside growths which constitute a fire hazard is becoming increasingly difficult, as conditions vary to such an extent that no set method of treatment can be adopted.

Miles of state highway are bordered by areas so situated and influenced by climatic conditions, that they produce a varied assortment of grasses and weeds in the spring months. This growth matures very rapidly and requires only a short period of hot weather to convert it into a dangerous fire hazard, particularly menacing to adjacent property in view of its proximity to the traveled way.

Various methods of eradication have been tried out, including cultivation, mowing, scything, spraying with oils and chemicals, and burning. Of these, burning appears most effective, though considerable risk attends its operation, and the resulting appearance is anything but attractive. During the present year some 632 miles of roadsides were burned over by the maintenance crews in certain locations under the direction of rangers from the Division of Forestry, Department of Natural Resources, at an average cost of $36 per mile. Of this amount some 20 per cent represents cooperation furnished by adjacent property owners directly benefited by this burning. Through careful handling but six small fires resulted from these operations.

On the southerly portion of the Ridge Route the entire highway right-of-way for a distance of 29 miles was cleared of a heavy growth of brush and grass at a cost of approximately $15,000. However, a destructive fire in that region demonstrated that even an 80-ft. fire break is not effective on windy days.

While the area burned has undoubtedly proved of immense benefit to the adjacent property owners, the blackened roadsides are not inviting to the motorists. During the coming biennium, it is planned to mow, rake, and burn the valley roadsides, removing the growth adjacent to the fence lines either by hand scything or burning, depending on the ability to properly protect roadside trees during the operation.

In the foothill sections where fires from the rank growth menace the adjacent grazing or pasture land, early burning will be resorted to.

Consideration is also being given to early spring spraying of roadside growths with non-poisonous chemicals which dry the plant and hasten the period of burning. This, however, due to its cost, will be tried out only where conditions preclude less expensive methods.

Obnoxious Weeds.—The control of obnoxious weeds is at present confined mainly to puncture vine, yellow star thistle, and mustard weed. While control is assured within the right-of-way, complete eradication is contingent on the adoption of effective measures on privately owned property. Since this has generally been lacking there can be no hope for diminution of the present task, as the agencies of reseeding are constantly at work.

Of the weeds mentioned, puncture vine is the most serious infestation, and the major share of the efforts are directed toward its control. From its original introduction in the southern portion of the state the spread has been rapid, due to the many varied and effective agencies of seed distribution. Railroad shipments from infected areas are chiefly responsible, though the sharp upward point spines, of which there are several to each burr, aid materially in their distribution by either automobiles or live stock. In general, control is exercised by applying low grade fuel oil (stove tops) with hand sprays or power spray machines mounted on light trucks, or by hoeing and scraping once a week and burning the plants cut out.

The following formula has been found most satisfactory and economical for power machine applications:

Stove distillate, 25 deg. to 30 deg. Baume, gal.	44
Caustic soda, lb.	1 to 4
Fuel oil (crankcase drainings are suitable), gal.	6
Water, gal.	50

This should be held constantly in emulsion by mechanical agitation while spraying.

During the 1928 growing season $8,813.39 was expended in puncture vine control by the various districts. This sum exceeds the 1927 expenditure by $591.

The work of puncture vine control has been carried on throughout the state in close cooperation with the State Department of Agriculture, and the respective county horticultural commissioners.

In addition to the "yellow star" numerous other species of thistles are found within the right-of-way and controlled by either mowing or hand cutting the plants prior to seed maturity.

Considerable success has also been had by treating this growth with a non-poisonous commercial weed killer which is sprayed on the green plant and carried to the root system. Effective kills have been made using a spray composed of water and 3 per cent of the weed killer applied at the rate of ⅛ to 1/10 gal. per square yard of surface treated. Due to the corrosive action of the chemical special spraying equipment is necessary.

Roadside Treatments. — Widespread interest now shown in the natural scenic beauty of the roadsides has injected new ideas which are bound to preserve and enhance the same. The following measures are indicative of the general procedure which is being followed in this work:

1. In daylighting a road, brush or trees are not cut on the upper side of the road where the cut bank itself prevents visibility. Exception is made in locations of heavy rainfall where accompanying winds might dislodge trees, causing damage to roadway or hazard to traffic.

2. Trees on the lower side of road are cut only when pruning will not give the desired visibility. Undergrowth, interfering with visibility, is removed; the extent of this removal to be a minimum.

3. All tree and brush cutting is done in the late fall or during the period of least traffic, and the slash burned in time to allow new growth to come up the following spring, covering both scars of cutting and site of burning.

4. When necessary to cut a tree, the cut is made flush with the ground. Existing stumps, except redwood and others of large diameter, are treated in a similar manner.

5. Ferns, flowers and moss growth on the cut bank and along the highway, except where they present a distinct fire hazard, are disturbed as little as possible.

6. Trees, shrubs, and where conditions and facilities permit, wild flowers common to the locality are planted along the fence enclosure of each maintenance station as an illustration of the state's desire for beautifying the highways.

7. The trimming and pruning of trees and brush in each district are laid out and supervised by a responsible man as instructed by the arboriculturist.

8. A section shall be selected in each district, one mile or less in length, representing average conditions, and as soon as practicable, treated as outlined above. On completion, this section to be reviewed as an object lesson

by the various maintenance foremen in that district.

9. Where a distinct fire menace exists, the traveled way, to a point on the cut bank 2 ft. above the gutter line, should be cleared of all dry vegetation.

Roadside Trees.—Public interest in roadside beautification is best exemplified by the fact that since 1920 civic or other public bodies have planted some 685 miles of highway roadsides to trees.

The initial expense of planting and maintenance during the first year is borne by the parties interested, the trees being secured at a nominal price from the state nursery near Davis. At the end of this period the state assumes their entire care, and replacement in event of loss.

The extent of this responsibility is appreciated, when it is known that some $66,000 was expended during the past year for the care and replacement of the plantings, a sum representing 1.2 per cent of the maintenance allotment.

That these plantings have a utilitarian as well as aesthetic value is evinced by the recent amendment to the "Federal Aid Act," which permits the expenditure of federal aid money in the planting of shade trees, where in the judgment of the United States Secretary of Agriculture and the State Highway Department it is practical to plant and maintain trees along the highways.

Generally the trees are spaced at 50-ft. intervals, being placed alternately on the right and left sides of the roadway, with necessary elimination for visibility at crossings and road intersections. The care of these trees is very exacting and is usually assigned to the individual foreman in whose territory they occur. Assisting in the direction of this work is the arboriculturist, reporting to the maintenance engineer.

Special tree watering equipment having a movable discharge pipe enables watering to be done from the driver's seat, a tank truck of 1,200 gal. usually being sufficient to water some 30 to 40 trees. This watering must be performed every four to six weeks during the period from June to October. Aside from irrigation and cultivation many precautions are necessary for the protection of young trees against insect pests, damage by squirrels, gophers, moles, and loose stock driven along the highway. The hazard of fire is also great.

Particular attention is given the location of plantings to eliminate any possible interference with the ultimate development of the pavement. With this in mind, new plantings are discouraged on rights-of-way less than 80 ft. wide. On 80-ft. rights of way the trees are planted between the curb and right of way line, 31 ft. out from the pavement center.

As load clearances require a clear height of 12 ft. above the pavement, systematic pruning and trimming are being followed to provide this clearance and at the same time develop a symmetrical, worth while tree. Where power or telephone lines occur within rights-of-way planted to trees, the tree height is limited to 40 ft. and all trimming for wire clearance is done by the utility company under permit and inspection of the division of highways.

Observations extending over a period of years indicate the suitability of the following tree species for the localities specified:

Valley sections: European Sycamore, California Black Walnut, Black Locust, Blue Gum, Red Gum, Carolina Poplar, Silver Maple, Arizona Ash, Valley Live Oak. Of these species the European Sycamore, Black Walnut, Arizona Ash, and Black Locust are preferable.

Coastal section: Coast Redwood, European Sycamore, Black Walnut, Blue Gum, Red Gum, Coast Live Oak, Silver Maple.

Desert section: Black Locust, Arizona Ash, Blue Gum, Red Gum, Black Acacia, Athol.

Owing to the susceptibility of the elm to the present widespread beetle infection, the planting of this species in any section of the state is not advisable.

Motor Vehicle Accidents Increase

An average of more than 3 deaths in the United States every hour of every day in July was caused by motor vehicle accidents. This in the face of the myriad safety factors that are built into and that surround the modern highway and city street.

Cities, states, railroad companies and automobile manufacturers now spend millions of dollars annually to protect and preserve all citizens who participate in present day vehicle and pedestrian traffic. Yet motor vehicle deaths in July exceeded those in June, and the total deaths to date in 1929 show an increase of 6 per cent as compared with the similar period of last year.

The first seven months of 1929 saw an estimated total of 15,900 persons meet death on America's highways and city streets. This number is only a small portion of the great army of victims who were not killed, but of whom many were maimed for life, many never will walk again, some will never see, each of them a personal tragedy and an economic loss to the nation.

Representative states report about 35 serious non-fatal accidents to each fatality. On that basis, more than one-half million persons can be estimated as the toll of serious injuries in traffic thus far in 1929. Based on the studies of costs of motor vehicle accidents made by the statistics committee of the National Conference on Street and Highway Safety, a conservative figure of the cost of highway accidents for this year will reach above one billion dollars.

Stirred to action by the ever-soaring figures on traffic deaths, the traffic committee of the American Road Builders' Association is sponsoring its third annual highway safety campaign.

A survey is being made with a view to ascertaining what remedies might be most effective in halting this fearful loss of human lives.

It has been found, according to the association, that proper measures for safety are going into the building of highways and of vehicles to operate over them, and that the greater blame, as in all previous investigations, must be laid at the door of the reckless driver and the unwary pedestrian.

Consulting the National Safety Council figures for July, it is found that pedestrian deaths continue to lead the list of traffic fatalities, taking 54 per cent of the total number. Thirty-seven per cent of these pedestrians killed were children under 15 years of age.

The American Road Builders' Association believes in furthering and increasing the education of children along highway safety lines. It is heartily in favor of school lessons, drills and plays on the subject, of school boy patrols and of all other methods that will instill caution into youthful minds.

Not the sort of education that will break down youthful spirits by thoughts of constant danger, but the development of ingrained caution, such as that which keeps a child away from a red hot stove.

As for adults, drivers or pedestrians, the association believes that they can be taught highway safety most effectively by practical, uniform laws that apply to all moving traffic, whether pedestrian or vehicular, and their rigid and impartial enforcement.

Pedestrians should obey traffic laws to make streets and highways safe for themselves and for drivers. There can be no safety where one group of traffic moves under strict regulation with traffic lights and police direction, while at the same time, in the same area, another group moves as it pleases, with no regulation at all.

There were 90 less motor vehicle fatalities in Chicago during the first six months of 1929 than during the corresponding period of 1928. There were 4,000 arrests for speeding, reckless driving and running through stoplights for the first six months of 1928, and 10,000 such arrests during the first six months of 1929.

Chicago's experience is evidence that strict traffic law enforcement pays well in human dividends. These additional 6,000 arrests probably had much to do with the saving of 90 lives.

Traffic laws, however, must of necessity be practical and of a nature to speed traffic movement, rather than slow it down. No amount of safety devices or safety education will change the habitually reckless driver or pedestrian. It requires laws and their enforcement.

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An Electromagnetic Theory of Sea Breezes

Ever since men began scientifically to speculate on the cause of winds one theory has held almost complete dominion over their minds. We refer to the convection current theory. On the third page of his "World Weather" (1923) Clayton expresses the general opinion of meteorologists when he states that winds are caused by differences in atmospheric density, the sun being the analogue of the stove in a room.

Even after the editor had found that the general circulation of the air is due to electromagnetic whirls, he remained for some time of the opinion that the local day and night changes in the direction of the wind, particularly near large bodies of water, are probably due to convection currents; but recently he has come to believe that even in such cases electromagnetic whirls play the major part.

As stated in previous articles, the editor's theory of cyclonic air whirls of all sorts is that the magnetic fields of the earth and of its upper ionized air (Heaviside layer) cause free electrons to rotate about the magnetic lines of force. These rotating electrons impart motion to the molecules of air, and cyclonic whirl-belts are produced. The same electromagnetic energy that gives rotation to these cyclonic air-whirls causes them to ascend until they bend over and descend as anticyclones. This theory certainly holds true of the 12 permanent cyclones that the editor has located, and there is not the slightest remaining doubt that it holds true of the migrating cyclonic whirl-belts that produce the barometric "lows," followed by their anticyclones that produce the barometric "highs."

Let us now consider briefly some of the reasons why even local sea and land breezes may also be electromagnetic whirls. Clayton shows (p. 4) the drift of smoke in a local sea breeze. During most of the day time such a breeze blows from the ocean carrying any smoke inland for a distance, then the smoke ascends, bends over and returns seaward, hugging the earth. This is precisely the way in which the air of a cyclonic whirl behaves; it ascends, bends over and returns to the earth. But why should there be local cyclonic whirls of this nature over the land rather than over the sea in the day time?

During the day time the air over the land becomes hotter than over the sea, hence it liberates more electrons. But there is another factor that affects the liberation of electrons, namely the pressure of the air. As pressure decreases more electrons are liberated. It follows that the most highly electrified air will exist at an elevation of a few hundred feet over the heated land. Consequently there will develop in this upper layer of land-air many small cyclonic whirls, and since they are all magnets with their north poles adjacent they will repel one another. This causes a march of these small cyclonic whirls toward the area of least magnetic resistance, which is seaward. As they lose their whirling energy these serried ranks of small cyclonic whirls break up and descend over the sea. The sea air flows in along the surface of the ocean onto the land, to take the place of the cyclonic air that has moved seaward. Instead of one large cyclonic whirl, such as constitutes a cyclonic storm, we have here a multitude of very small cyclonic whirls that tend to push one another apart, and thus produce an upper current of air flowing seaward from the land in the day time.

Thus far the convection theory and the electromagnetic whirl theory seem to be about equally matched in ability to explain local sea-land breezes. But it should be noted that the convection current theory is really a chimney theory, and loses nearly all of its merit if the height of the chimney is slight and the body of moving air is great.

A sea breeze in northern Chile (20° to 25°S) "often breaks with a roar that heralds its coming an hour in advance." Such a sudden and intense beginning is not characteristic of any convection current, whereas it is characteristic of electromagnetic phenomena. As above stated more electrons are set free as temperature rises, and the ascending air-whirl by reducing pressures causes further release of electrons. Hence, there is a sort of combustible and often explosive development of an air-whirl. It is a well known fact that tornadoes exhibit a rapid building up into a whirl of great intensity. The action of sunspots, which are known to be electromagnetic whirls, is similar to that of giant tornadoes. Hence when any sea breeze shows such cyclonic characteristics, as do those in Chile, we may assume that all sea breezes have the same characteristics, although usually in milder form.

When a great forest fire is well under way, it undoubtedly causes strong convection currents, but the editor has yet to see one in which the air flows back in the direction from which it came. On the contrary, if there is no general breeze, the smoke ascends almost vertically to great heights, showing no tendency like a sea breeze to bend back and return to its source.

That there are intense but small electromagnetic whirls within the area of a forest fire is made evident by the way in which sparks and smoke jets suddenly leap upward to considerable heights, almost as if fired from a gun. Only the other day a newspaper article on a forest fire said: "Sparks flew hundreds of feet with only a slight breeze." The reporter added that the flames seemed to have produced a vacuum that sucked the sparks along; but he seemed ignorant of the fact that any such vacuum could not be thus produced.

It has long been observed that local thunder storms tend to generate over dry, heated areas of land. This

has been explained as being evidence of a chimney of hot air; but what causes the air whirl that is often so conspicuous? Certainly convection can not cause it. Nor can appeal be here made to changes in centrifugal force on the earth, for the storm often travels a distance too small to make such differences sufficient to account for the whirl. On the other hand, a heated area is favorable to the release of electrons and this is favorable to the generation of electromagnetic air-whirls. It should be added that in these air-whirls the electrons become concentrated so as to form a sort of hollow cylinder. This results because electrons moving in the same direction attract one another, whereas those moving in opposite directions repel one another. Consideration of this principle explains why an exceedingly low barometer exists near the center of a tornado, and why there is a general inward flow of the air surrounding it. Since the electrons on opposite sides of such a cylinder are moving in opposite directions, they repel one another. This tends to increase the diameter of the cylinder, and, aided by centrifugal force, ultimately disrupts the cylinder.

Progress Dependent Upon Freedom

Herbert Spencer, in his monumental treatise on Sociology, traces the evolution of governments and social customs. He shows that there has been a slow but certain trend toward individual freedom. There has been an accompanying industrial progress, but it is not often realized that the latter has been largely dependent upon the former that freedom is essential to progress.

In extreme forms of absence of freedom, such as slavery and serfdom, it was long ago evident that progress is brought to a halt. Study discloses that even the milder forms of mental bondage retard progress, often greatly. Thus where labor union leaders dictate to their followers the maximum amount of work that they shall do each day, individual freedom is curtailed in what seems to be a mild manner, but with disasterous results eventually. Witness the soft-coal miners of America and workers in almost all the British trades.

When curtailment of freedom is mentioned one is apt to think only of governmental restrictions, but, as Spencer repeatedly points out, unwritten social customs are often much more restrictive of individual freedom than are written laws. Take, for example, the caste system that prevails in India. It forbids intermarriage of castes; it forbids sons from entering trades other than those of their fathers. In a thousand ways it says "Thou shalt not." The result of such a surrender of freedom is a nation of paupers.

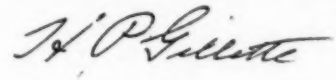
Turning to the other extreme we have America. By way of illustration of the difference between India and America we may refer to a recent questionnaire sent to a large number of American high-school boys which disclosed that not 15 per cent intended following the trade, business or profession of their fathers. In India no such questionnarie would be dreamed of. Custom, for immemorial ages, has settled that question; and in settling it as it did, custom also settled progress.

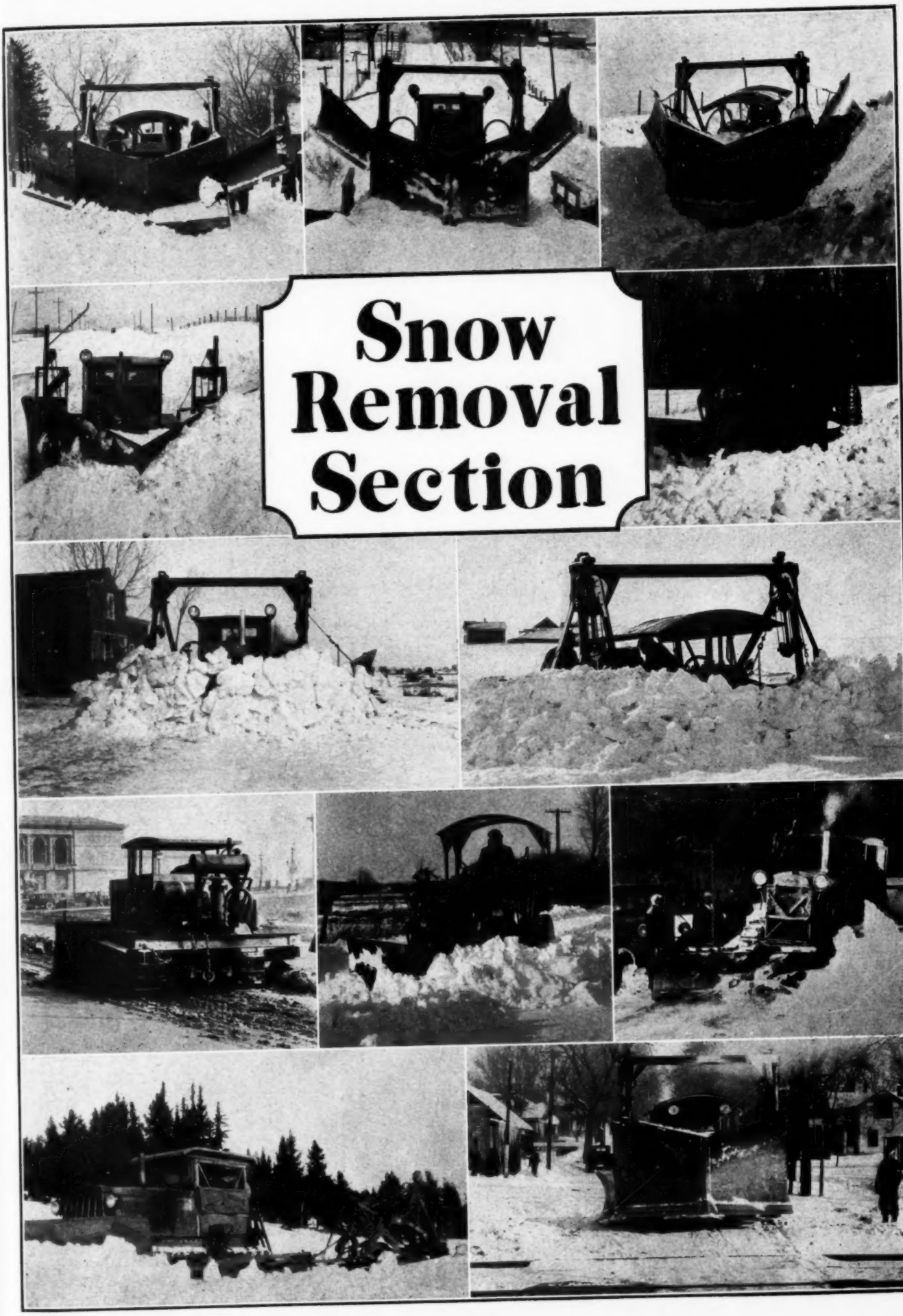
When a labor union restricts the number of apprentices and the output of workers it is adopting the basic principles of the Indian system of caste. All that remains is to admit no apprentices save sons of union members, and to secure the sanction of society and a religious blessing. Then the evolution into Indian caste would be complete.

Fortunately for progress, evoluton in America has been steadily toward greater freedom. Our great use of machinery has hastened this evolution; for by endowing machines with the skill that hand craftsmen were years in acquiring, our workers have become free to change quickly from one occupation to another with little or no loss in income during the transition period. This in turn has acted to reduce overproduction. Overproduction occurs wherever the actual demand for a product falls short of the supply. It is seen in its worst form where men can not, or will not, shift from one occupation to another. Given perfect freedom to change jobs and ability to produce as efficiently in one occupation as another, and it follows that overproduction never becomes very serious, for there is always some sort of goods for which the demand is increasing.

In this connection it should be remembered that advertising has become a great factor in stimulating demand in America. Where else in the world could a new industry like radio spring almost full grown from the head of an industrial Jove? Advertisements on every side have beckoned the multitude to buy radios, and they have bought at such a rate that almost every family in America owns a set. Realization of the rapidity with which this industry has grown is had upon reading what so recent a book as the 1922 Encyclopedia Americana has to say on the subject. To begin with you will not find the discussion under the head of "Radio," but under "Telephony, Wireless"; and there you will not find a single word indicative that the writer anticipated that many people would ever use radio sets to receive musical and other entertainment. In the paragraph headed "The Future of Wireless Telephony" we read: "In view of the rapid development of wireless telephony within the past 8 or 10 years it would be unwise to attempt to place a limitation upon the extent of the use of this art within the next decade." Thereupon the writer proceeds to talk about sending telephone messages long distances over sea, and grows prophetic in picturing a world-wide telephone system operated without wires. Well, that is exactly what has not yet developed and seems unlikely to develop for a long time. On the other hand, wireless telephony as a rival to the phonograph, which that writer did not vision, has become an enormous industry.

The point that we wish to make is not the difficulty of prophesying the development of a new industry, but the amazing rapidity with which a new industry may develop in a country where freedom and intelligence exist. We need not flatter ourselves that we are the most intelligent of humans; but we should never cease congratulating ourselves that we are the freest.





Snow Removal Section

How the Various States Are Handling Their Snow Removal Problems

Notes on Operations in Winter of 1928-29 Obtained from Questionnaire Sent to Highway Departments of States in the Snow Belt

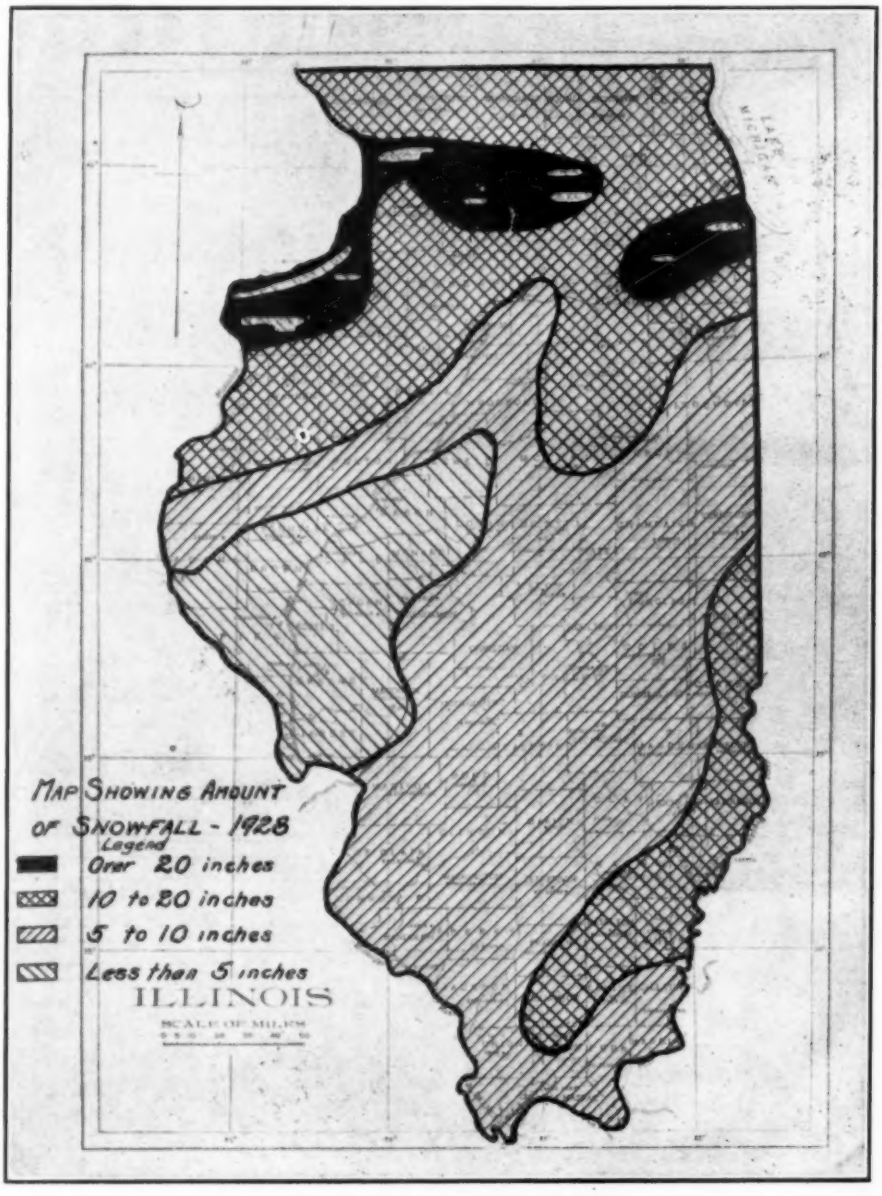
IN planning a program for the removal of snow from the roads during the winter season to come, officials are naturally concerned with the efforts those responsible for snow removal in neighboring and in distant sections of the country are preparing to make. To secure detailed data on the work the various state highway departments have done in the past and are preparing to do during the season to come, as well as statistical information covering the conditions that must be met in the several sections of the country, "Roads and Streets" addressed a questionnaire to the highway departments of those states in which snow is a hindrance to winter travel. In this questionnaire, the following specific requests were put:

1. How much was spent last year on snow removal?
2. What methods, in general, did you pursue? How did you handle the problem?
3. What governmental subdivision has control of snow removal?
4. How many outfits were employed? What type?
5. What cost data have you been able to secure on individual storms?
6. Did any special problems occur? If so, how were they handled?
7. What was the average seasonal snowfall?
8. How much snow fence have you employed? What is your opinion of the effectiveness of snow fence?
9. Can you give an example of how spring maintenance costs are reduced by snow removal work and fall cleaning of ditches?
10. What experimental work have you done?
11. Did you employ any special equipment methods or arrangements?
12. What traffic or economic studies have you made on winter travel? How do you determine when snow removal programs are economically justifiable?
13. What additional equipment do you think you should have?
14. Do you think present snow control equipment should be changed or improved? How?

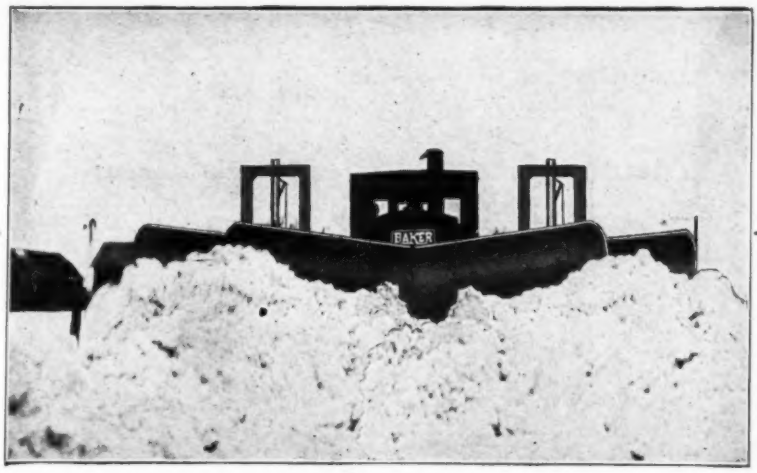
In listing replies, the numbers attached to the questions above will be referred to as far as this is possible. Where answers to specific questions are omitted, it is an indication that specific information is not available.

Illinois.—Frank T. Sheets, chief highway engineer, gave the following answers to the questionnaire:

1. $156,582.39.
2. Snow removal work started when about 2 in. of snow had fallen on the road. Heavy trucks with V-type and straight blade snow plows were the principal units. Work continued both night and day and every effort was made to prevent blockades.
3. On state roads the work was handled by the regularly organized forces of the state highway maintenance department.
4. Three hundred six heavy trucks with straight blade and V-type plows were available; also 35 Caterpillar tractors and 9 large V-type plows, together with a sufficient number of heavy graders. A few trucks were rented during emergencies.
5. No cost data are available for individual storms. Maintenance patrolmen at $125 per month and no overtime were principally the men employed. Day labor help was paid 40 to 60 ct. per hour for time work. In emergencies the men worked until the roads were cleared or until the men were exhausted. Relief forces were put to work as fast as they could be organized. Work was pushed 24



Snow Fall in 1928 in the State of Illinois



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Baker Snow Plows for Motor Trucks and Tractors consist of over twenty models, each design to fit certain power units and to do certain work. There are "V" plows with side wings—"speed" truck plows—tripping blade plows for city pavements—plows for bucking deep drifts—for attachment to any standard motor truck or leading industrial tractor. The dependable service that thousands of Baker Plows have given for so many years is a guarantee that you will be pleased with the way they move snow.

Check and mail the coupon below and get literature on Baker Snow Plows

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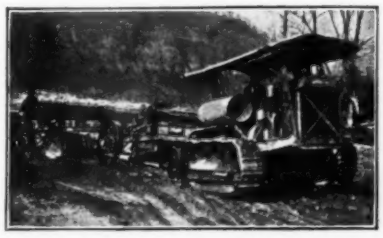

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The "original self loading scrapers" are proving to thousands that the Baker Maney way is a clean-cut labor saving proposition. The ability to move 500 to 1000 yards a day with one train using only two or three men means moving more dirt per man. Now made in three sizes—¾, 1 and 1¼ cu. yd. capacities.

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These one man scrapers are now made in 4 ft., 5 ft., 6 ft., and 7 ft. sizes with capacities from 17 to 40 cu. ft. for light and heavy tractors. Automatic features permit operation without stopping. No backing up—one rope control — narrow replaceable cutting edge — bigger capacity—remarkable strength.

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506

hours a day and every day until roads were cleared.

7. The average seasonal snowfall is shown on the accompanying map.

8. About three miles of snow fence was employed. It was effective in preventing heavy drifts but did not eliminate the need for the snow plows.

10. We have experimented with snow fence to find its effectiveness. We have found that snow fence reduces drifts. We have also studied the relation of shapes of snow plows and speed of trucks. We believe speed plows essential for this state, but have occasional storms which make speed plows ineffective.

11. Administrative control is through nine districts with offices throughout the state. A definite territory is assigned to heavy trucks and a certain number of reserve units are kept to replace breakage or supplement the local units. A method of reporting road conditions to the district offices and reporting from the district offices to the main office at Springfield is used in order to determine the area affected by the storm. Units outside of this area can then be moved toward the center of heavy snowfall.

12. The public demands that roads be kept open to traffic. The volume of traffic on the road is sufficient to warrant snow removal. At one point where a blockade occurred, more than 100 automobiles were stalled in snow drifts over night.

13. The department now has sufficient equipment to take care of all roads which have been improved.

14. Our present organization is satisfactory, but can be improved by further study of distribution of units before snow begins to fall. More attention should be given to reporting road conditions to central headquarters in order to supplement the local units with reserve equipment where necessary.

Snow Removal on a West Virginia Highway

A West Virginia Highway After the Plows Have Been By

West Virginia.—For the season of 1928-29 West Virginia kept 1,137.81 miles of roads on the state system under surveillance for snow removal, A. J. Mills states.

The total cost of snow removal for the season was $14,761.63.

The method followed consisted of systematic snow patrols, with equipment ready to start from strategic points at any hour of the day or night. After being called out, the crews worked continuously until the roads were clear.

The State Road Commission of West Virginia had full charge of the program. The amount of this kind of work done by the counties and districts (townships) was almost negligible.

Equipment used consisted of 90 trucks, 41 truck displacement plows, 2 truck rotary plows, 7 tractors, 1 tractor rotary plow, 4 tractor displacement plows, 37 graders.

Not much snow fence was used. The total length was 18,560 ft.

On account of the comparatively low cost, we consider that snow removal is always economically justifiable on an improved road.

Nevada.—S. C. Durkee, State Highway Engineer, gave the following answers:

1. During the winter of 1928-29 the Nevada State Highway Department spent $15,115.61 for snow removal purposes.

2. Late in the fall and just prior to the storm season, the snow removal equipment is placed at different points along the state highway system in preparation for the work, and whenever the amount of local traffic justifies the expense the roads are kept open. When the snowfall reaches a depth of from 2 to 3 in. the snow removal operations are started and in order to avoid an accumulation the operations are continued throughout the storm. After the storm, the division office is notified of the condition of each section coming within the storm area.

3. Administratively speaking, the snow removal work is in direct charge of the division engineers.

For maintenance and engineering purposes the state is divided into five engineering divisions, with each division containing division offices, maintenance repair shops and storage yards. Each division office is located as near the geographic center of the territory covered by the division as possible. The highway system in each division is divided into maintenance sections varying from 10 to 60 miles in length, depending upon the type of road and volume of traffic.

4. During the past winter, the department operated eight snow removal outfits. The equipment available for this purpose consisted of three rotary-type snow plows, three push plows, fifteen trucks, ten tractors, seven large road graders and several heavy-duty trucks equipped with special frames.

5. Individual storm cost data were not recorded, as the snow removal operations were dovetailed into the general maintenance work.

6. Each snow removal job was a special problem in itself, as the snowfall varied from 0.6 in. to 87 in. The maximum snowfall was in the mountainous localities. Heavy wind storms were numerous during the winter, which increased the amount of work on the roads over the mountain passes.

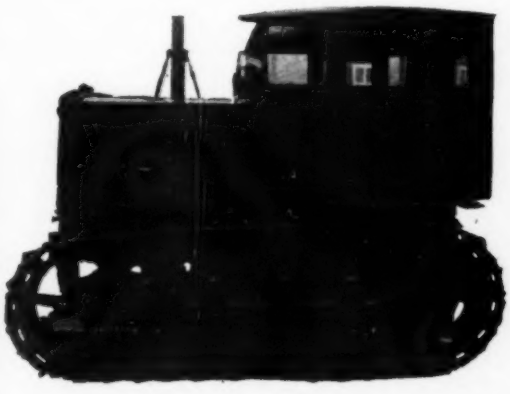
7. It is impossible to average the seasonal snowfall in this state on account of the extreme variations and

Another View of Snow Removal Work in West Virginia

"No trouble to keep this road open now!"

"WITH this equipment our roads are always open—the Bates 'Steel Mule' puts the plow thru the worst drifts and we have SNOW in this country. . . ."

Keep your roads open with a Bates "Steel Mule"—They have unusual *Traction* and plenty of reserve power to operate under severe weather conditions.



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Snow Removal Scene on a Nevada Highway

the area under arid and semi-arid conditions. For the last winter, the snowfall was considerably below normal over the greater portion of the state; however, in the northeastern portion it was above the average. The wind movement was far greater than normal and caused most of the trouble which was encountered in keeping the roads opened.

8. We employed approximately one mile of snow fences for controlling wind movement. In some localities the snow fence was very effective; in others, it was not so good. Special attention was given to the results obtained with snow fences and in accordance with the results secured we decided to increase the operations in this method of protection from wind movement.

9. As an example of reducing spring maintenance costs we experimented with the following method:

Just prior to the storm season earth dikes were bladed on the outside of the fills wherever material was available. All roadway ditches and diversion ditches were cleaned out and diversion boxes were installed to take care of the run-off from the roadway section. By diversion of the run-off from the roadway the fill slopes were protected from excessive wash. Wherever it was economical the full width of the roadway was kept clear of snow.

10. The only experimental work done was in the line of diverting surface waters.

11. The only special method used in our experimental work was the building of the diversion dikes along the outside of the fills.

12. It is very hard to state just the amount of work that is economically justifiable, as our snow removal program is of minor importance and does not call for extensive traffic or economical study.

13. On account of dove-tailing the snow removal operations with the general maintenance we have sufficient equipment for snow removal purposes.

14. There is no doubt about the need of improvement in snow removal equipment for heavy snow removal work.

Note the Height of the Snow Cut on This Nevada Road

Michigan.—The following information on snow removal work in Michigan was furnished by B. C. Tiney, Maintenance Engineer, State Highway Department:

1. During the winter of 1928-29 the state highway department of Michigan maintained for wheel traffic 7,272.99 miles of state trunk-line road at a total cost of $705,095, or an average of $96.95 per mile.

2. Methods pursued in this work were similar to the previous years' practice and consisted largely of maintaining a smooth surface of good travelable width by patrol with motor trucks equipped with displacement plows. Banks thrown up by these plows were then thrown back and the roadway was widened by the use of rotary plows and displacement plows on 10-ton tractors. Drift prevention by means of snow fence was carried on more extensively.

3. The state highway department had general administrative control of all snow removal work on the state highway system.

4. General types of equipment and number of units used were as follows:

a. Number of motor trucks equipped with displacement plows—564.

b. Number of motor trucks equipped with rotary plows—3.

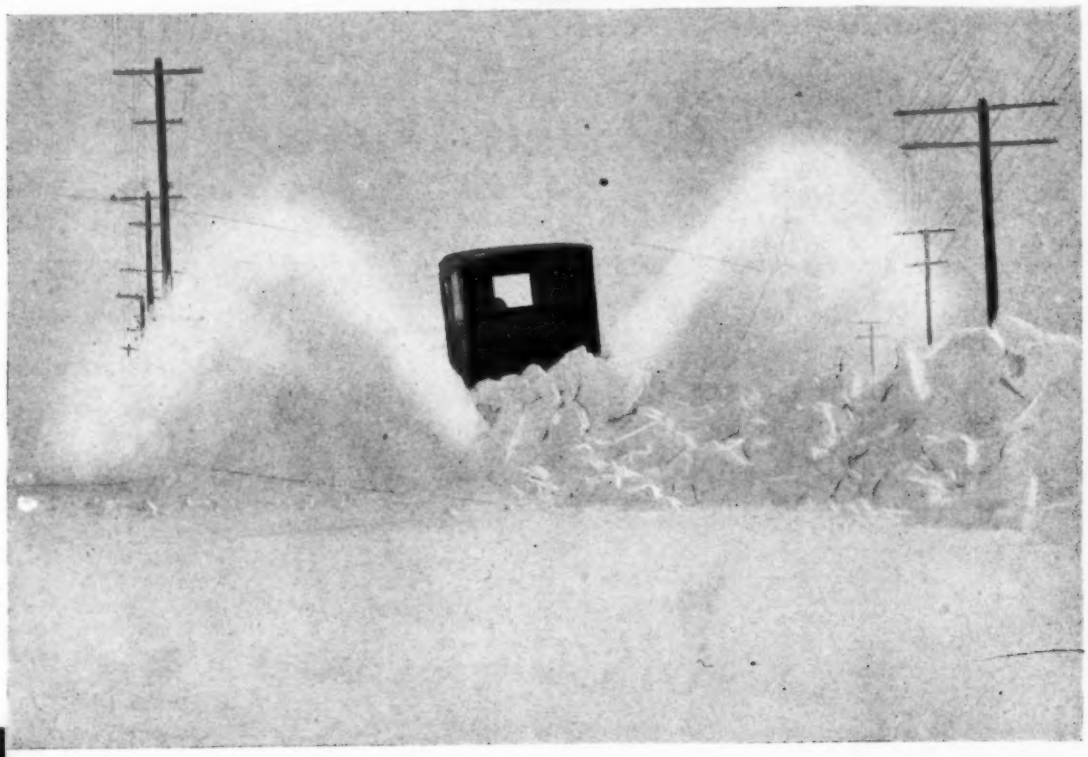
c. Number of tractors equipped with displacement plows—77.

d. Number of tractors equipped with rotary plows—63.

5. We have no costs available on individual storms. Rates of wages vary considerably over different parts of Michigan, inasmuch as our highway labor rate usually conforms to the prevailing wage scale in that part of the state, and wages are higher in the south or industrial portion of Michigan than they are in the northern part of the state. In general, wages varied from 35 to 50 ct. per hour. The number of hours work per day varies greatly inasmuch as our equipment is kept in continuous operation during and after storms until the roadway is cleared.

6. A special problem which arose during the past winter was the excessive amount of ice existing on highways

Sure Footed FWD Trucks



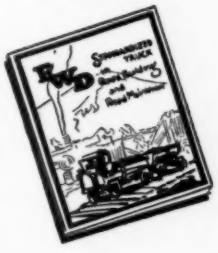
Counties use them in fleets

because they speed up snow removal work...

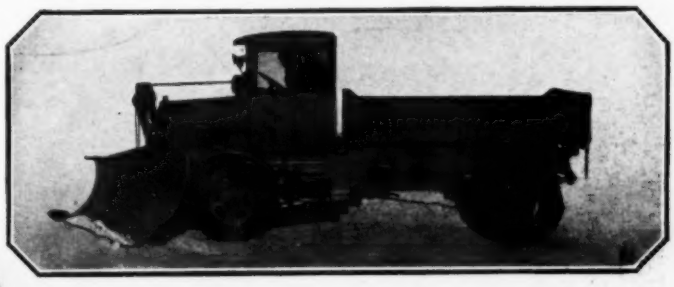
AT the first fall of snow flurries, hundreds of counties in the "Snow-belt" rush their FWD Trucks into service . . . and keep them in "harness" for the winter because their sure footed traction and dependable power has made them outstanding in this application.

FWD Trucks are readily adaptable to snow removal work . . . they can be used with any type of plow . . . they are capable of traveling at a good rate of speed . . . they drive and brake on all four wheels . . . they are economical to operate. Let us give you detailed information . . . send for special snow removal bulletin. Write today.

FWD Trucks are made in 2 to 10 ton sizes . . . four wheel, six wheel and tractor trucks. Send for bulletins.



THE FOUR WHEEL DRIVE AUTO COMPANY
CLINTONVILLE, WISCONSIN



FWD

BACKED BY NATION WIDE SERVICE

in the southern part of the state for a period of more than six weeks. This was caused by a very wet snow which turned into rain and resulted in a slush which was frozen before it could be removed from a large mileage of road. The hazard to traffic from this slippery condition of roads was very great, especially on hills and curves and adjacent to railroad crossings and stop signals. An attempt was made to remedy this condition by application of sand on icy pavements at critical locations. A number of different types of sand spreaders were tried. It was found that this sanding operation had to be repeated almost daily on our heavy-traffic roads. The use of calcium chloride mixed with sand was found advantageous, as it thawed the surface of the ice slightly and embedded the sand. We are of the opinion, however, that the use of a considerable quantity of calcium chloride for this purpose is liable to cause scaling of concrete pavements the following spring, and we believe that the amount of chloride used with sand should be very small. This is still an open problem with this department and we hope to do something further toward its solution during the coming winter.

7. The total snowfall in different parts of Michigan for the winter 1928-29 varied from 13.7 in. to 135 in. The average snowfall for the state was 55.6 in.

8. Approximately 400 miles of snow fence was in place on the state trunkline system last winter and we believe that it is very effective in reducing our costs by prevention of drifting of snow on the roadway.

9. We have no specific data on this matter, although it is a practice in our organization to see that all drainage structures are open in the fall, and that they are cleaned out in the spring as soon as possible.

Rotary Snow Plow in Action in Berthoud Pass, Colorado; 4 to 5 Ft. of Snow on May 12, 1929

12. While our winter traffic is considerably less than summer traffic in many parts of the state, we feel that the importance of open roads in isolated regions cannot be measured entirely by the number of vehicles. Traffic using the roads in the winter in the northern part of this state is important traffic, such as commercial traffic, doctors visiting patients, school buses, etc. We feel that even in some cases where traffic is not over 100 vehicles per day, the snow removal work is justified.

13. Additions to our equipment this year will probably not be as large as in former years. A definite statement as to additional units is not available at this time.

Virginia.—The cost of snow removal work is thoroughly justifiable in the opinion of J. J. Forrer, Assistant Engineer, Maintenance, who replied as follows:

1. As our snow removal is handled by our regular maintenance crews, no special cost is kept, unless it is necessary to employ additional or emergency labor. This was not necessary during the past winter, the snow being very light; however, I should estimate that the cost of our maintenance crews during the snow removal season was probably $10,000.

2. A maintenance patrolman or patrol gang foreman is solely responsible for a certain mileage on the state system and it is his responsibility to remove the snow. He requisitions such equipment as he needs to do the work.

3. The state of Virginia has 100 counties and the state is divided into eight districts, with a district engineer and three resident engineers in each district. The district engineer, with his resident engineers, is solely responsible for all the work in his district.

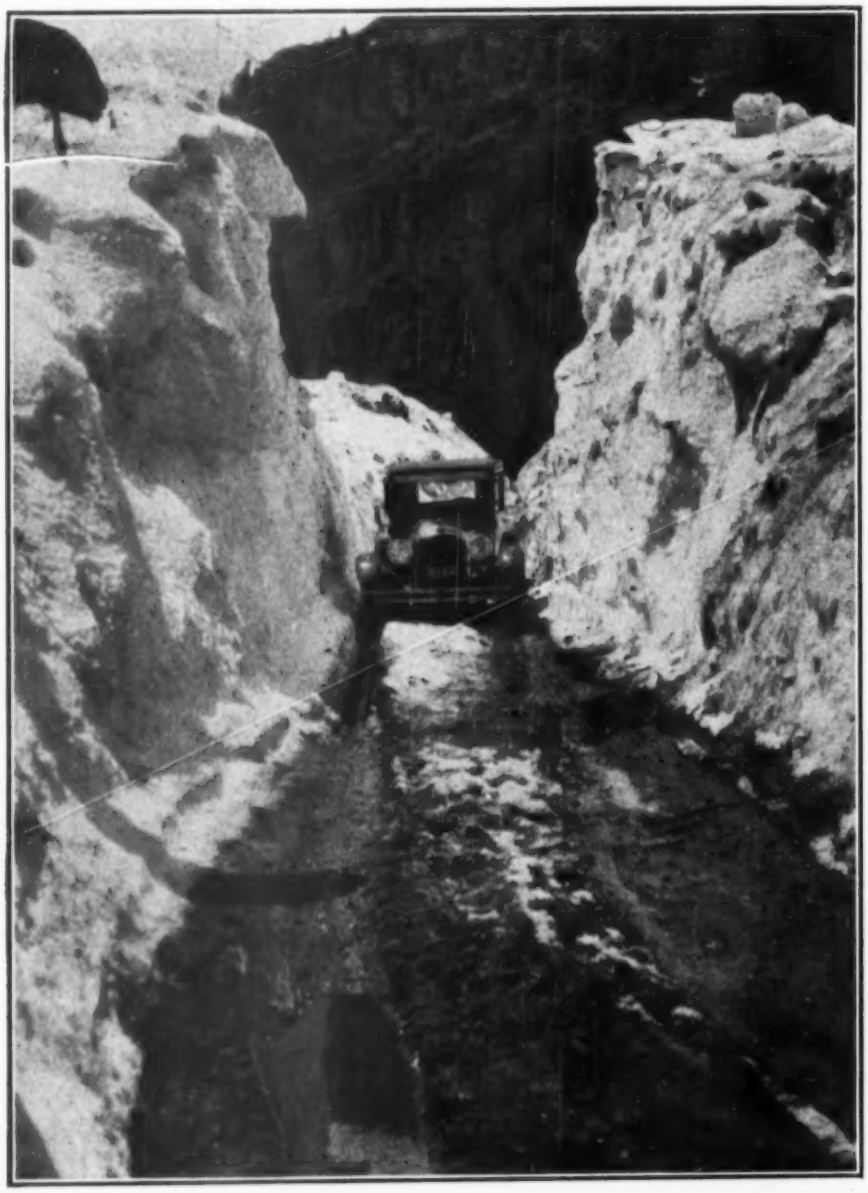
4. For removing the snow last winter we used 30 snow plows attached to trucks, 15 snow plows attached to tractors and 90 road graders.

5. We have no cost data on individual storms.

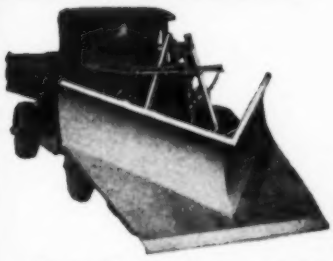
6. No special problems occurred.

7. The average seasonal snow fall is probably from 4 to 6 in.

8. We have about two miles of snow



Cut Through Slide on Ouray-Silverton Road, Colorado. This Slide Occurred May 24, 1929, Covering Road for 2,000 Ft. At the Deepest Point It Measured 45 Ft. from Road Bed to Top of Snow. It Was Necessary to Tunnel and Blast from Road Bed



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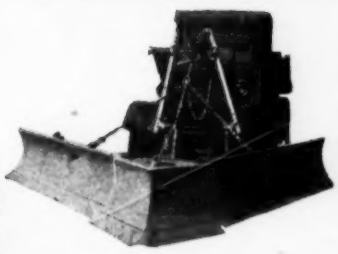

A name and symbol synonymous with the best — and most highly developed — equipment

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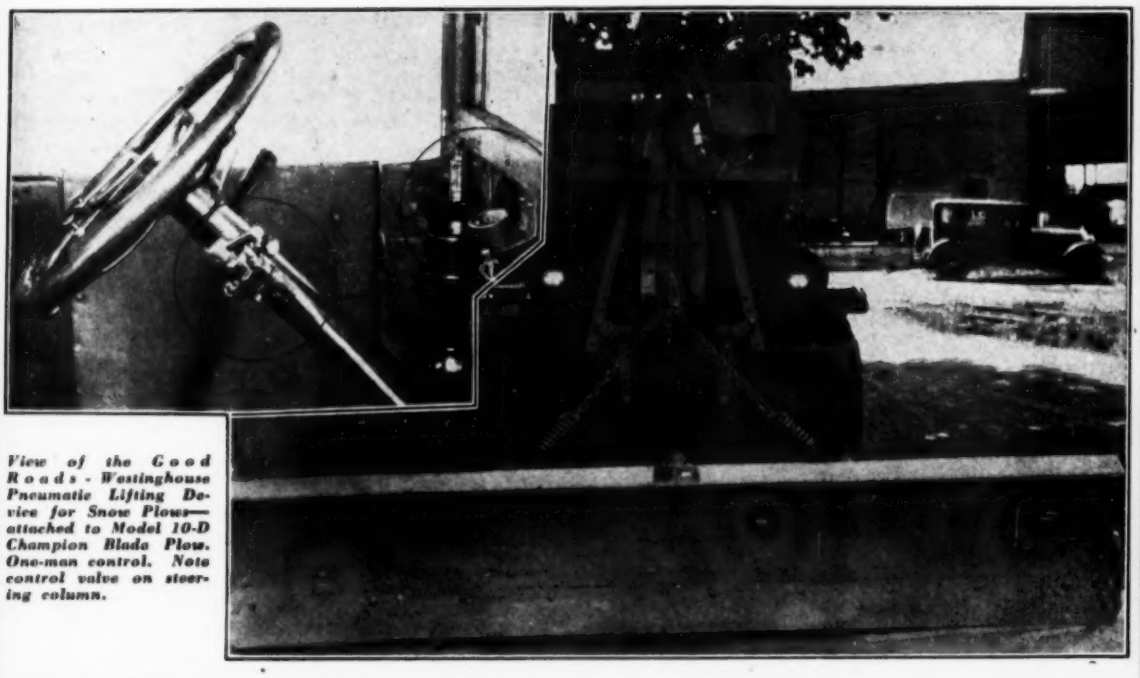
"Good Roads" Champion Snow Plows — in various Types and many Models to meet every condition



View of the Good Roads - Westinghouse Pneumatic Lifting Device for Snow Plows— attached to Model 10-D Champion Blade Plow. One-man control. Note control valve on steering column.

Specializing in Snow Removal equipment for attaching to motor trucks and buses — The pioneers in the building and development of such equipment.

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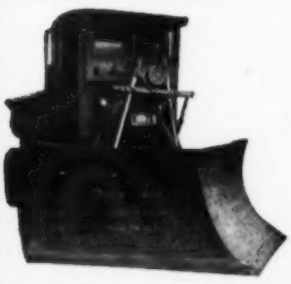

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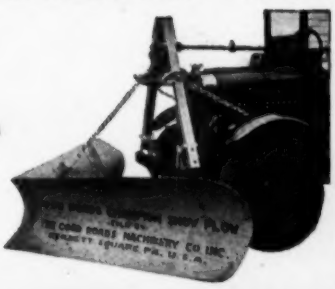


"A business established and in continuous operation for fifty-two years—at Kennett Square in Pennsylvania"

fence which is very effective when properly located.

9. In answer to this question it would be a big guess. We know that to clean ditches and to remove snow certainly reduces road failures materially.

10. No experimental work.

11. No special equipment.

12. As traffic is allowed to move the same in winter as in summer the snow removal cost is thoroughly justifiable. While we have not kept any exact figures we believe that the automobile tax collected during the snow season would more than pay for the snow removal.

13. We are fairly well equipped now and do not anticipate any further equipment, except possible plows for 2-ton trucks.

Wyoming.—The following information concerning snow removal in Wyoming was furnished by Z. E. Sevison, State Highway Engineer:

1. $77,719.66.

3. The state highway department has control of snow removal on state highways.

4. Last year, 17 snow plows, mounted principally on trucks or tractors, were employed.

5. No data on individual storms are available. Most employees are paid at a rate of from $115 to $165 per month. Extra common labor is hired at 50 ct. per hour. The hours worked are determined by the duration of a storm and the conditions met.

8. Snow fence has proved very effective; in other words, prevention is cheaper than removal. About 10 miles of fence are in use.

13. Additional units of equipment should comprise high-speed four-wheel-drive trucks equipped with blade plows. The V-type of plow has been found unsuitable in Wyoming, where much wind prevails during the winter months.

14. Present equipment is generally satisfactory, but insufficient in number of units to meet the situation adequately.

Rotary Snow Plow Working on Drift in Berthoud Pass. Drift Was 23 Ft. High and 1,600 Ft. Long

North Dakota.—T. G. Plomasen, Maintenance Engineer, Department of State Highways, gives the following outline of snow removal in North Dakota during the winter of 1928-29:

1. We spent $70,637.09 on 3,500 miles of highway.

2. Our 400 horse patrolmen worked on snow removal, each one on his section of road doing whatever he could. Their work consisted mostly in keeping the snow fence in condition and opening up a few cuts where conditions were not too severe. Our trucks and caterpillar engines operated out of the centers of population and on the principal highways.

3. The Department of State Highways has charge of snow removal on the constructed portions of the state highway systems. At the present time the length is approximately 4,000 miles.

4. Four 5-ton four-wheel-drive trucks with V-type push plows.

Two 3-ton four-wheel-drive trucks with V-type push plows.

Six 3-ton four-wheel-drive trucks with rotary snow plows.

Two 60-hp. Caterpillar tractors with V-type push plows.

One 60-hp. Caterpillar tractor with rotary snow plow.

This equipment is owned and was operated by the department.

The following is a list of equipment owned by counties and operated on state highways a portion of the time, for which work the counties were reimbursed by the department:

Four 60-hp. Caterpillar tractors with V-type push plows.

Three 60-hp. Caterpillar tractors with rotary snow plows.

6. Our problem is how to keep the roads open when the winds blow. This can only be accomplished by building the grade line high enough above the ground line so the wind will keep the roadway clear. Where this cannot be done, snow fence can be placed to keep the snow off the road.

On our trunk-line highways the right-of-way should be wide enough to get all obstructions back a sufficient distance from the shoulder of the road to allow for drifting snow. This will also give us some place to shove the snow. Right-of-way on trunk lines should not be less than 100 ft. wide.

7. The average seasonal snowfall for North Dakota is 32 in. However, this snow is blown back and forth considerably by high winds.

8. We have 1,096,000 lin. ft. of snow fence.

Snow fence is very effective and better results are obtained from an investment in snow fence than snow removal.

We are purchasing 520,000 lin. ft. of wood-slat snow fence this month.

9. Spring maintenance costs are reduced only by proper, thorough, systematic snow removal work. Snow removal half done is far worse than none, and results in great injury to the road in the spring.

11. We used six rotary snow plows on four-wheel-drive trucks.

12. We have conducted no economic studies. It is very hard to figure beforehand whether a snow removal program is justifiable or not, as it is never known how much work will be required.

Traffic may justify an expenditure of a certain sum of money, but this amount may not insure an open road.

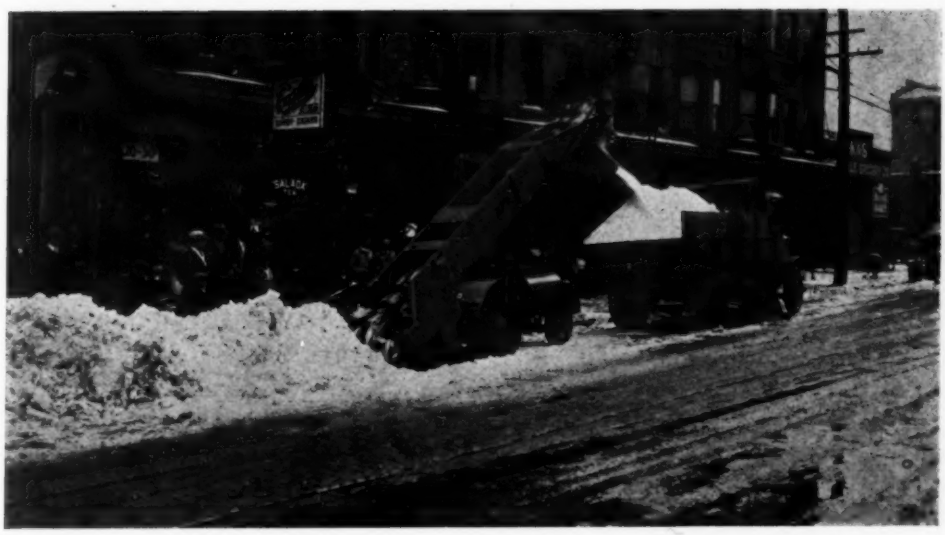
13. What we need more than snow removal machinery are roads designed for 365 days of traffic.

Roads of this nature cost considerably more than ordinary summer roads and perhaps the expenditure is only warranted for trunk lines.

14. On roads of this type very little change need be made in snow re-

A Typical Snow Condition in North Dakota When Roadway Is Not Opened Full Width

Dollar for Dollar
or Yard for Yard



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for High-Speed Snow Removal

will load more snow for less money
than any other snow-loading equipment made

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That is why there are
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The N. P. NELSON IRON WORKS, Inc.

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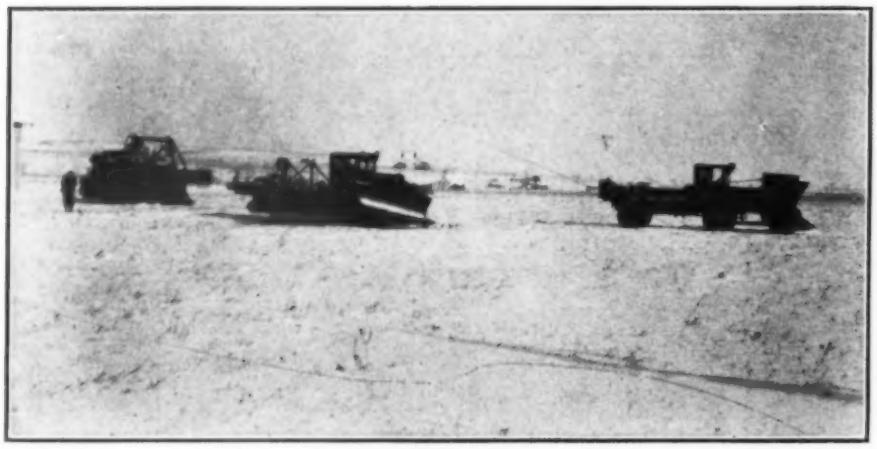
it does not pay to shovel by hand when one Nelson

does the work of a hundred men



Snow Removal Equipment of State Highway Department of North Dakota; Stationed at Bismarck

moval equipment. A 5-ton four-wheel-drive truck equipped with a V-type push plow of the proper design can do 90 per cent of the work necessary. On the ordinary road with a low grade line, the problem is to dispose of the snow. For this work considerable improvement should be made in the existing equipment.

Massachusetts. — The Massachusetts Department of Public Works has been desirous of carrying on a fairly extensive experimental program of snow removal, it is stated by A. W. Dean, Chief Engineer, but the snowfall for the past several years has not been sufficient to permit of any experiments from which it would be safe to draw definite conclusions. The questions are answered as follows:

1. $157,261.69.

2. This department uses at present two types of equipment: 3 and 5-ton trucks equipped with blade plows and 5 and 10-ton tractors equipped with V-plows. The trucks work in tandem and start with the storm. If the storm persists, the tractors are then put to work in order that they may throw back the snow accumulated by the trucks, and also to be more promptly available if required in case of an emergency.

3. Department of Public Works.

4. 300 trucks; 23 tractors.

5. No data are available on individual storms; cost approximately $115 per mile for snow removal last winter. Foremen receive $6 per day for 8-hour day, chauffeurs $1 per hour, helpers 75 ct. per hour and laborers 50 ct. per hour.

7. 44 in.

8. 30 miles; this snow fence has proved very effective.

9. Fall cleaning of ditches undoubtedly reduces spring maintenance costs but it is not believed that snow removal has any such effect.

12. No traffic or economic studies have been made on winter travel. No studies were required to enable the department to know if the snow removal programs were economically justified on the routes that have been selected. Such studies will not be required until it is proposed to extend the program to lesser used routes.

Kentucky.—Concerning snow removal from Kentucky highways, W. M. Jarvis, Engineer of Maintenance, states that climatic conditions are such that only at rare intervals does the state experience snowfall of a sufficient depth to require the use of grader equipment for its removal. Thus the matter of snow removal is of slight consequence, and does not demand serious consideration from the highway department.

In the winter of 1928-29, the southeastern portion of the state experienced a 30-in. snowfall within a period of less than 18 hours. Traffic was tied up for about a day while road grader equipment cut one-way passages along U. S. Route 25. However, under normal conditions, a recurrence of such a condition is not to be expected within the next decade.

Tennessee.—Frank W. Webster, Maintenance Engineer, State Highway Department, replies that Tennessee experiences about one snow per five years which exceeds 3 in. in depth and which will justify removal. Practically all average snows in the state melt in from 24 to 36 hours.

Last year the state had only one storm, in which 12 in. of snow fell. This lasted no longer than a week. For removal from the highways, approximately 30 Caterpillar tractors of the "30" and "60" types were used with suitable graders. Tractor drivers and men on the graders were paid 35 ct. per hour; labor was paid 30 ct. per hour. Except in cities, such snow removal work as is required in Tennessee is under the control of the state highway department. Last year $10,000 was spent on snow removal.

Pennsylvania.—An extensive program of snow removal is carried out by the Pennsylvania Department of Highways. The following replies were furnished by W. A. Van Duzer, Assistant Chief Engineer:

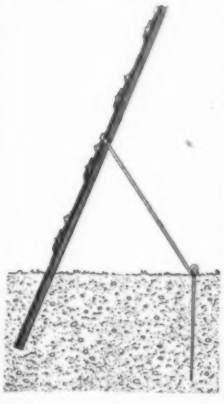
1. The cost of snow removal for the winter of 1928-29 was $899,682.25. This total is itemized in the following table:

Item	Amount	Total Amount
1. Placing and Removing Snow Fence:		
Equipment	$134,332.87	
Labor, teams and material	79,364.61	
Total		$213,697.48
2. Removing Snow:		
Equipment	217,792.94	
Labor, teams and material	120,520.90	
Total		338,313.84
3. Placing Cinders, Chips, Etc., on Icy Roads:		
Equipment	160,798.78	
Labor, teams and material	139,888.34	
Total		300,687.12
4. Snow Removal Direct Overhead:		
Equipment	519.28	
Labor, teams and material	46,464.53	
Total		46,983.81
Grand total		$899,682.25

2. The drivers are called when the snow starts falling and the trucks start

Snow Removal at Bernardston, Mass.

The above shows "Blizzard Buster" three banks deep protecting Highways at Ft. McKenzie just after their worst blizzard. Drifts were 10 to 15 feet high in places but the "Blizzard Buster" stayed clear and effective to the last.



Cross Section of Setup

Most Economical

from every standpoint

365 DAY HIGHWAYS

Thanks to the Northfield "Blizzard Buster"

— Pressed Steel Snow Fence —

A highway covered with snow is no better than no highway at all—One protected with "Blizzard Buster" is open to normal traffic the year 'round.

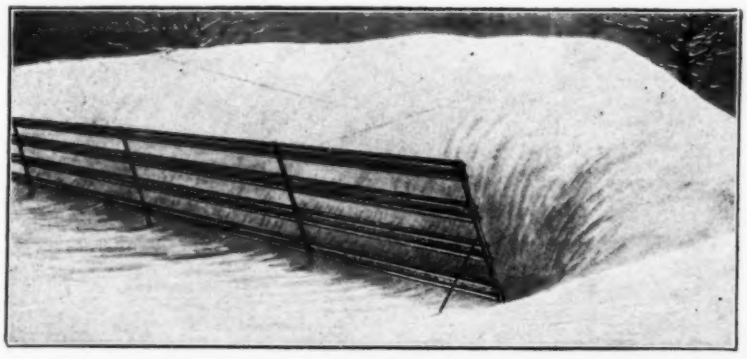
It is well and good to remove snow from the highways, but better yet, prevent the snow from reaching the highways. Properly placed "Blizzard Buster" snow fence will do this under all conditions. The illustration at the top of the page shows a large area protected by "Blizzard Buster." It can easily be seen that the "Blizzard Buster" snow fence prevented the great majority of the snow from reaching the road at all. The Government Officials at the fort and Veterans Hospital were highly pleased with its performance.

The illustration above shows a drift formed on the windward side of a snow fence installation on Jefferson Highway in Minnesota. The highway was kept clear and traffic uninterrupted for the first time.

Light—Strong—Demountable—Portable

These Posts Can Be Easily Driven in Frozen Ground Without Damage.

"Blizzard Buster" fence is unique—designed and sold for sand and snow control only—built with unusual strength—easier taken down and easier erected—compactly stacked and carried from place to place—it *is* the ideal fence for snow or sand control. Fire and Rot Proof. Guaranteed for 30 years.



This unique snow fence will remove many of the burdens of winter maintenance and snow control from your highway department's shoulders—it will lower costs, assure traffic movement, and keep the road in better condition to meet the spring thaws. Also a success for stopping sand drifting. Write for specifications and literature today.

100% Tested— And Approved!

"Blizzard Buster" has been thoroughly tried in some of the outstanding states in the snow belt—In every case it has given satisfaction. Cuts, hollows, intersections and numerous places along highways, that have never been kept clear of snow during the winter months, were kept in perfect condition and open to traffic at all times.

— Distributors Wanted —

Manufactured by NORTHFIELD IRON COMPANY 494 Nico Street Northfield, Minn.

working as soon as the snowfall reaches a depth of 2 in. The equipment continues to plow snow until the storm ceases and the roads are opened. Should heavy drifts be encountered, the tractors equipped with rotary plows are placed in operation. Hand labor is used in opening drains, ditches, etc. The snow plows are located so that they can control the sections allotted them. The rear-wheel-drive trucks cover a section of from 10 to 15 miles, while the four-wheel-drive trucks cover from 20 to 25 miles.

3. The state is divided into eight divisions, each division being in charge of a division engineer. Working directly under the division engineer is an assistant engineer of maintenance, who is responsible for the snow removal work in the division, which comprises from five to seven superintendents' districts. Each superintendent's district is comprised of approximately 175 miles on the snow removal program.

4. The following equipment was employed:

633 trucks.
249 moldboard truck plows.
376 V-type truck plows.
8 rotary truck plows.
109 tractors.
88 V-type tractor plows.
21 rotary-type tractor plows.
1 snow loader.
1 super truck (equipped with a rotary plow on one end and a moldboard plow on the other).
76 power graders.

5. No cost data are available on individual storms.

6. As far as is known, no special problems occurred.

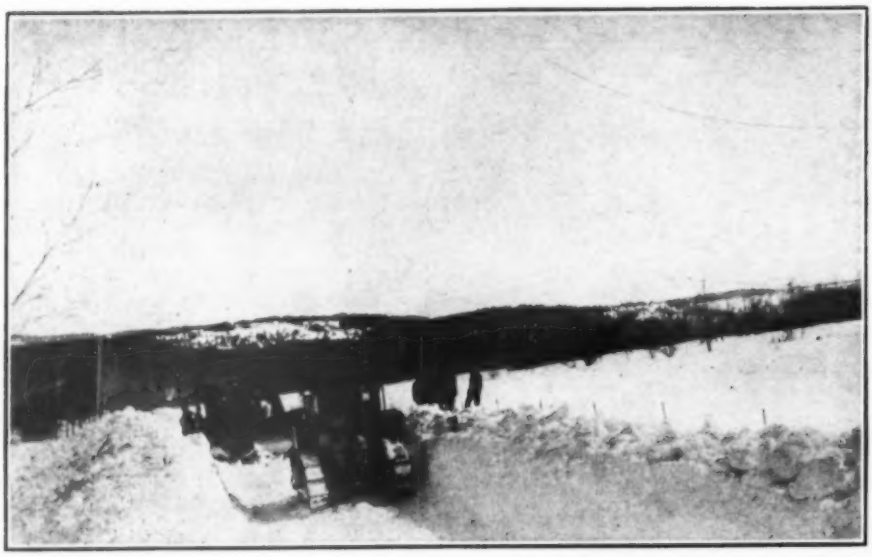
7. Yearly snowfall figures are as follows:

Winter	Snowfall in In.
1923-24	48.0
1924-25	43.0
1925-26	50.4
1926-27	35.0
1927-28	40.9
1928-29	28.0

8. The department has approximately 2,200,000 ft. of snow fence and by the aid of this fence we endeavored to control an equal depth of snow on the entire roadway. This snow fence has proved very effective in our state. After learning the drifting conditions, we are able to spot this fence and allow our truck plows to take care of an entire section, while prior to the location of this fence it was necessary to place tractors and rotary plows at the drifting locations.

Massachusetts Snow Removal Work in Windsor

9. On temporary or non-rigid types of construction, such as bituminous surface-treated macadam roads, it is very essential that the snow be removed. If allowed to remain on the surface the traffic travels in one path and the melting and freezing of the snow confined in the ruts cause disintegration of the roadway. It is essential that not only the traveled surface of the roadway be cleared but also the berms for a distance of 18 in., and that all waterways opened.



Removing the Snow from a State Highway in Town of Windsor, Mass.

11. The department has purchased eight 5-ton four-wheel-drive trucks on which were mounted rotary plows. The reason for the purchase of these trucks and plows was to experiment with their ability to remove snow as compared to the tractor and rotary snow plow. We found from experience that the heavy four-wheel-drive trucks and plows were approximately ten times as portable as the tractor and were just as efficient as the tractor in heavy drifts.

12. On our main hard-surfaced highways we feel justified in removing the snow for the convenience of the traveling public and for the saving made by this snow removal in our maintenance cost.

13. Our department is in need of additional four-wheel-drive pneumatic-tire trucks to take care of the additional mileage built during the present construction season. These will be placed on the 1929-30 snow removal program.

14. The Pennsylvania Department of Highways guarantees a 24-hour schedule on all main traveled highways throughout the state. It is not believed that any improvement upon this standard could be made.

Montana.—R. P. Neuland, Maintenance Engineer, State Highway Commission, states that answers to the questionnaire, in the case of Montana, are apt to be misleading unless the Montana law is thoroughly understood.

The state of Montana maintains only those portions of the system which it has constructed; consequently many miles of the state highway system are still maintained by the counties. On but few sections does the state have complete jurisdiction between centers of population. Thus it is useless for the state to remove snow, except in isolated instances, unless the counties also handle the situation on their sections.

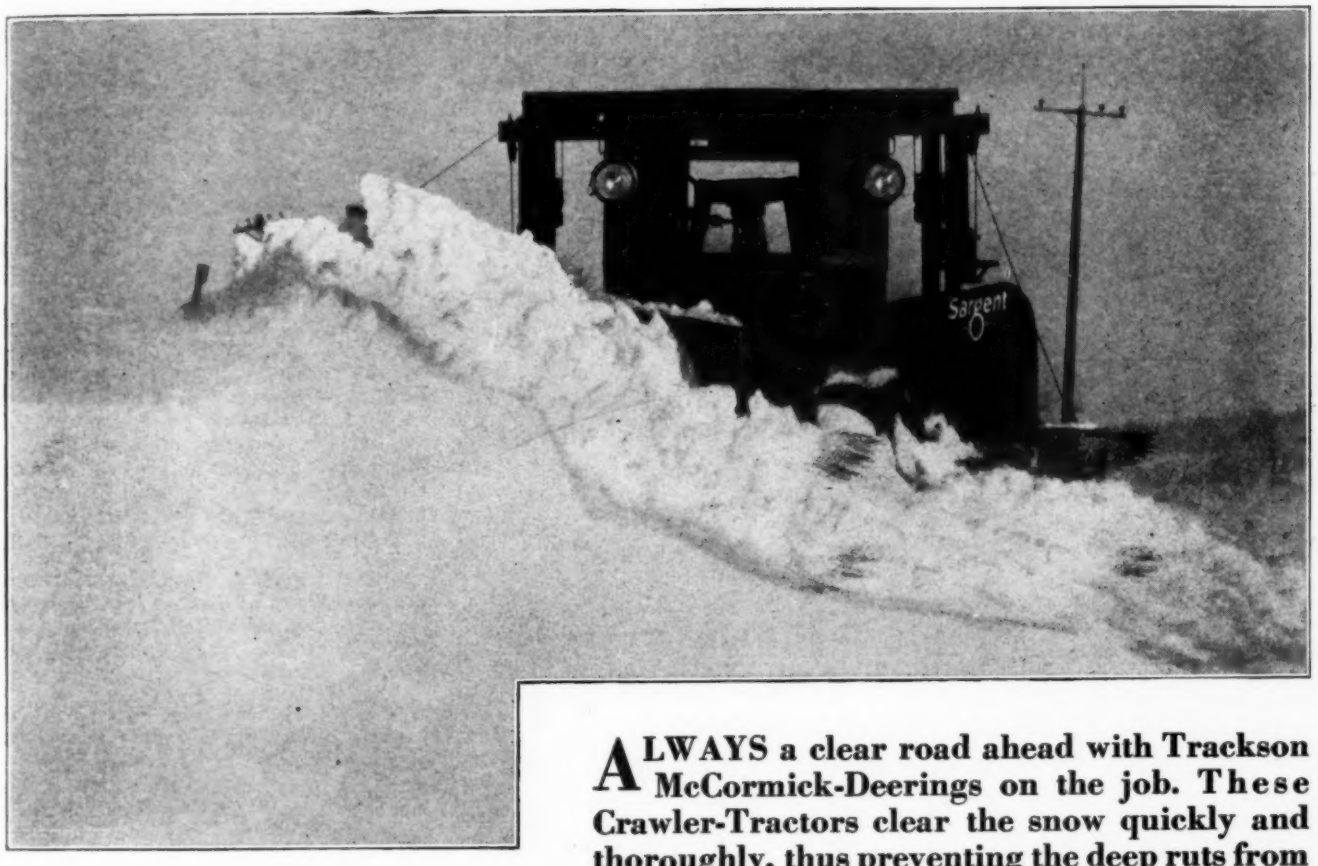
With this in mind, it is seen that Montana has not yet been able to engage in any systematic snow removal program. As far as is possible, the questionnaire is answered as follows:

1. Approximately $12,000.
2. Snow removal was turned over to counties generally, the state participating only at selected points.
3. State Highway Commission.
4. Equipment employed consisted of 14 push plows, 1 rotary plow, trucks, graders and motor graders.
6. No special problems were met.
7. 40 in.
8. 35 miles.
9. All sections where snow removal has been carried on have come through the winter in good shape.

13 and 14. Until the state highway system is connected up, there is no particular need of additional or improved equipment except to keep up with construction.

Missouri.—The snow removal problem in Missouri is described in the following paragraphs by C. W. Brown,

SPEED - *for the light falls*
POWER - *for the heavy drifts*



MODEL LH

ALWAYS a clear road ahead with Trackson McCormick-Deerings on the job. These Crawler-Tractors clear the snow quickly and thoroughly, thus preventing the deep ruts from traffic which later cause thousands of dollars in road repair. Their speed and power meet the most rigid requirements of snow removal. Their low first cost and low operating cost meet the most conservative community budgets. Their fewer parts and sturdy construction assure long service and least upkeep. When winter is over they supply the sure-footed power needed for road building and maintenance. See or write your nearest Trackson dealer for complete information today.

Trackson Company
FULL-CRAWLERS & TRACTOR EQUIPMENT

533 CLINTON ST. MILWAUKEE, WIS.

FULL CRAWLERS BULLDOZERS LOADERS SHOVELS CRANES

Assistant Chief Engineer, State Highway Department.

The state of Missouri covers such a range of latitude that its southern portion receives very little if any snowfall, while the central portion of the state, where traffic is heaviest, receives a moderate snowfall that as a rule calls for light snow removal equipment. The north and northwest portions receive the greatest amount of snowfall, and it is here that the greatest expenditures for snow removal were made in 1928-29.

The heaviest snowfalls occurred between Jan. 1 and Feb. 21. On Jan. 3 and 5, snow fell over the entire state, 4 to 6-ft. drifts occurring in the northern part of the state. From Jan. 26 to 31, state routes in portions of the northern part of the state were blocked for several days. From Feb. 1 to 7, two heavy snows were encountered in the northern part of the state. On Feb. 20, a heavy sleet followed a 4-in. snow in the southeastern part of the state.

View of a Massachusetts Highway After the Snow Has Been Removed

The present Missouri state highway system comprises 7,640 miles of marked and maintained highways. The Bureau of Maintenance, a branch of the state highway department, is charged with the responsibility of the proper maintenance of this system. The slogan, "Keep Traffic Moving," is ever before all employees of the maintenance bureau, and especially so at the first signs of snowfall. This slogan represents the policy of the highway department regarding snow removal on the state highway system.

The maintenance organization is comprised of approximately 860 full-time maintenance employees. Extra laborers are employed when needed. The highway department owns and has available for use all necessary modern road maintenance machinery. This equipment is evenly distributed over the entire state, as the patrol system of maintaining state roads is used.

This equipment includes 176 motor graders, 162 tractors, 415 trucks, 530 graders and a number of truck and tractor displacement plows. All of this organization and equipment is used for snow removal when needed.

In most cases snow removal begins with the start of snowfall. For protracted snowfall the regular maintenance employees are divided into two groups and supplemented with extra laborers. One group is permitted to rest while the other group works, thus allowing snow removal to proceed continuously with these 12-hour shifts.

In the late fall all snow removal equipment is made available for instant use, and men are instructed to provide themselves with proper clothing for their winter work of possibly long hours.

During the winter of 1928-29, 50½ miles of snow fence were used. Snow drift prevention for keeping winter roads clear of snow is now realized to be a major factor. The department is now in the act of purchasing 71 miles of additional snow fence for use during the coming winter, as snow drift prevention is found to be more economical than snow drift removal.

Snow removal costs during the 1928-29 period, amounted to $68,839.75. Over $46,000 of this expenditure was incurred in northwest, north-central and east-central Missouri. Over $12,000 was spent in the northeast, central and east-central parts of the state. The balance, amounting to approximately $9,500, was spent in the southern part of the state. Of this $68,839.75 expenditure, the salaries of regular employees amounted to $48,030.43, or a total of 66.8 per cent of the total cost. An expenditure of $8,121.41 was made for extra labor, which is 11.8 per cent of the total cost. Motor expenses amounted to 14.5 per cent of the total cost, or $9,907.76. Teams, material, supplies and tools, equipment repairs and general expense amounted to $4,726.15, or 6.9 per cent of the total cost.

As there was a registration of 712,965 motor vehicles in the state in 1928, the cost of snow removal amounted to $0.0965 per motor vehicle, a very small cost for the service rendered.

Throughout the snowstorm period, observations were conducted covering such items as the proper distance to place snow fence from the centerline of the road, the proper time to start snow removal work, the proper organization to carry on the work continuously and the type of equipment to use for most of the snow fighting work. It is believed that in the state of Missouri light detachable truck plows are best. It was found, during the season just past, that trucks equipped with light snow plows, and traveling at a fairly high rate of speed, removed a medium snowfall very quickly and economically. This has led us to purchase an additional number of light snow plows, especially designed for the department, for the coming winter's use.

The department also is considering the purchase of at least one rotary snow plow for use in extreme northern portions of the state where snowfall is the heaviest.

Attention is also being given at this time to providing better maintenance sheds for the protection of our equipment. If equipment cannot be easily started, a great inconvenience is encountered in getting out crews for snow removal purposes.

An effort is made at all times to keep at the highest pitch the spirit of the men employed in snow fighting work; for this type of work calls for courageous and loyal men. Methods of communication between county and district units are provided wherever possible. This is a wise precaution, as sometimes concentration of men is necessary.

Snow removal is also economical from the standpoint of annual maintenance, for spring maintenance costs are thereby reduced. Work of reconditioning gravel roads that have had the snow removed speedily after each snow storm is less than where the snow is allowed to melt on the surface.

The opening of side ditches is part of our fall maintenance program. This takes care of the snow water as speedily as it melts and is one item of maintenance not overlooked.

All these operations incidental to snow removal as well as the major operation of clearing the road for traffic pay because they reduce the cost of maintenance during the spring season.

Snow Removal at Boston, Mass.

The Organization, Equipment and Methods of Keeping Records and Handling Storms

DURING the year 1925, Mayor Malcolm E. Nichols, after consulting with the Boston Chamber of Commerce and other business organizations, appointed a committee for the purpose of organizing an extensive snow removal force. The committee consisted of Commissioner of Public Works James H. Sullivan, Commissioner of Buildings Louis K. Rourke and Rapid Transit Commissioner Thomas F. Sullivan. Messrs. Rourke and Sullivan were commissioners of public works under former administrations.

The Snow Removal Equipment.—After receiving the report from this committee, Mayor Nichols ordered the purchasing of the following equipment: 20 Mack trucks, 20 White trucks, 10 American LaFrance trucks and 10 G. M. C. 5-ton trucks. This was augmented by 9 Pierce Arrow trucks and 1 American LaFrance truck that had been used by previous administrations. All these trucks were equipped with Champion and Baker blade plows. Besides these trucks, 3 Mead-Morrison tractors, equipped with Walsh V-plows, 2 Holt & Best tractors, equipped with Sargent plows, 1 Monarch tractor, with Champion blade plow, 6 Barber-Greene and 2 Nelson snow loaders, and 3 Fordsons, equipped with W. & K. motor brooms, were purchased. A modern Mack wrecker, which is really a repair shop on wheels, and a Reo speedwagon, which is used to convey men to the snow headquarters and for emergency purposes, were also purchased. Since this equipment was purchased, a Walter four-wheel-drive snow fighter has been added.

This equipment is kept in the two main city garages, where the snow removal force make their headquarters. In order to be prepared for a storm in the night time, the chauffeurs of these trucks, which are used in the sanitary service for the collection of ashes and garbage when not on snow, are compelled to gas, oil and water their trucks after their day's work and to report any defects that would prevent them from from being ready for immediate use. Then 25 plows are assembled on the trucks, so that if a storm comes in the night time, the 25 trucks are all equipped.

City of Boston—Public Works Department

SNOW REMOVAL
PLOUGHMAN'S TIME SLIP

Name of Ploughman .....
Truck No. .....
Day and Date .....

LEFT GARAGE		Foreman	Returned to Garage	
A. M.	P. M.		A. M.	P. M.
12 00	12 00		12 00	12 00
12 30	12 30		12 30	12 30
1 00	1 00		1 00	1 00
1 30	1 30		1 30	1 30
2 00	2 00		2 00	2 00
2 30	2 30		2 30	2 30
3 00	3 00		3 00	3 00
3 30	3 30		3 30	3 30
4 00	4 00		4 00	4 00
4 30	4 30		4 30	4 30
5 00	5 00		5 00	5 00
5 30	5 30		5 30	5 30
6 00	6 00		6 00	6 00
6 30	6 30		6 30	6 30
7 00	7 00		7 00	7 00
7 30	7 30		7 30	7 30
8 00	8 00		8 00	8 00
8 30	8 30		8 30	8 30
9 00	9 00		9 00	9 00
9 30	9 30		9 30	9 30
10 00	10 00		10 00	10 00
10 30	10 30		10 30	10 30
11 00	11 00		11 00	11 00
11 30	11 30		11 30	11 30
A. M.	P. M.		A. M.	P. M.

City of Boston—Public Works Department

SNOW REMOVAL
CHAUFFEUR'S TIME SLIP

Name of Chauffeur .....
Truck No. .....
Day and Date .....

LEFT GARAGE		Foreman	Returned to Garage	
A. M.	P. M.		A. M.	P. M.
12 00	12 00		12 00	12 00
12 30	12 30		12 30	12 30
1 00	1 00		1 00	1 00
1 30	1 30		1 30	1 30
2 00	2 00		2 00	2 00
2 30	2 30		2 30	2 30
3 00	3 00		3 00	3 00
3 30	3 30		3 30	3 30
4 00	4 00		4 00	4 00
4 30	4 30		4 30	4 30
5 00	5 00		5 00	5 00
5 30	5 30		5 30	5 30
6 00	6 00		6 00	6 00
6 30	6 30		6 30	6 30
7 00	7 00		7 00	7 00
7 30	7 30		7 30	7 30
8 00	8 00		8 00	8 00
8 30	8 30		8 30	8 30
9 00	9 00		9 00	9 00
9 30	9 30		9 30	9 30
10 00	10 00		10 00	10 00
10 30	10 30		10 30	10 30
11 00	11 00		11 00	11 00
11 30	11 30		11 30	11 30
A. M.	P. M.		A. M.	P. M.

GMC-2/'25

Fig. 1—Ticket for Chauffeurs and Plowmen

TRUCK NO.

Ploughing District No. 1.	Pickup District No. 15.
Ploughing Route No. 22.	Federal St., Short High St.
Summer St., Devonshire St. to Dewey Sq.	Post Office Sq., then Congress St
Federal St., Summer St. to Milk St.	
Congress St., Purchase St. to Milk St.	
High St., Summer St. to Congress St.	

Fig. 2—Route Card for Chauffeurs

Use of Weather Forecasts.—During the day time, through the central office, the weather forecast is received twice a day from the United States Weather Bureau and from the Blue Hills observatory, which is maintained by Harvard University. At 8:15 a. m. and 10:30 p. m. E. B. Rideout, WEEI meterologist, broadcasts the local weather conditions, which are followed with much interest.

At the snow removal headquarters a chauffeur is assigned from 10 p. m. to 6 a. m., whose duty it is to watch for a snow storm. When the snow starts to fall he telephones the assistant supervisor, who compares his barometer and thermometer records and then calls the supervisor and gives him what data he has on hand. Before leaving his home for the snow headquarters, the supervisor calls the commissioner of public works and informs him of the conditions.

The Telephone Plays Important Part.—As soon as the supervisor or his assistant reaches the snow headquarters, the telephone plays an important part. Three lines are set apart for snow work. When the telephone office is notified that there is a storm, extra operators are assigned to these lines. On a call-board in the headquarters all chauffeurs of light or emergency cars are listed. These men are called; they have a prepared list of men for whom they are to call, and inside of two hours over 150 inspectors and men have been reached, either by telephone or automobile.

If the storm looks as if it will be severe, the foreman of the shops is notified to bring his gang to equip the rest of the trucks with plows. Also the sanitary supervisor is called and he notifies the foremen in the business, railroad and market districts to bring in skeleton gangs to take care of the important stations until such time as the regular force reports for its day's work.

How the Records are Kept.—As soon as the chauffeurs and plowmen report at the snow headquarters their tickets are made out and the time of reporting is punched (see Fig. 1). They are then assigned to a truck and the chauffeur drives his truck into the yard, where it is ballasted. This consists of putting a 2-yd. box filled with sand in the truck by the aid of a large electric derrick. The chauffeur then reports back to headquarters and a printed route card is given him (Fig. 2), with instructions that he plow the streets listed on the card for the duration of the storm, unless otherwise ordered.

The greater part of the snow equipment is used in the downtown section, comprising the shopping, railroad and market districts. This section is divided into 15 plowing districts, consisting of 44 plowing routes.

Each district is in charge of an inspector and, as the trucks assigned to him leave the headquarters, he is given an inspector key card (Fig. 3). His duty is to see that all streets in his district are properly plowed.

While this unit is getting under way, taking care of the important sections of the city, another unit, which is known as the contractors' plowing division, is on call.

The foremen in the nine outlying districts notify the contractors to report to their several yards with their plows ready for work. As soon as a contractor's truck reports to the yard, the names of the contractor, the chauffeur and the plowman are taken and the crew is assigned a route. This infor-

CITY OF BOSTON.

Public Works Department. Snow Removal Force.
Ploughing District No. 1. Inspector's Key Card.

DEWEY SQ.			
SUMMER ST.,	Devonshire St.	to	Atlantic Ave.
DORCHESTER AVE.,	Congress St.	to	Summer St.
CONGRESS ST.,	Milk St.	to	Dorchester Ave.
ATLANTIC AVE.,	Stuart St.	to	Congress St.
FEDERAL ST.,	Summer St.	to	Milk St.
HIGH ST.,	Summer St.	to	Congress St.
BEACH ST.,	Atlantic Ave.	to	Albany St.
LINCOLN ST.,	Summer St.	to	Stuart St.
SOUTH ST.,	Summer St.	to	End of street.
ESSEX ST.,	Kingston St.	to	Atlantic Ave.
PURCHASE ST.	Congress St.	to	Federal St.
UTICA ST.			
COLUMBIA ST.			
TUFTS ST.			
EAST ST.			
STUART ST.,	Atlantic Ave.	to	Albany St.

Fig. 3—Inspector's Key Card

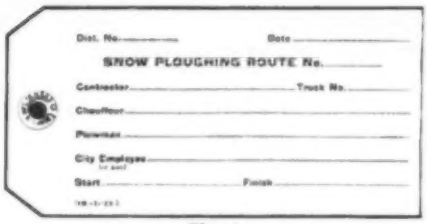


Fig. 4

mation is telephoned in to the inspector in charge at headquarters, who recopies it on a tag (Fig. 4), which is hung on a chart, thereby making it possible for the supervisor to know at a glance what routes are not being plowed.

These outlying districts comprise 87 routes, which are taken care of by city plows and contractors. They plow the key streets and feeders. Their orders are to start plowing when 2 in. of snow has fallen.

George H. Foss, supervisor of snow removal, and his assistant, Thomas J. Watson, carry key cards on their tour of duty. If a street is found that is not plowed to their satisfaction, by consulting their key card they can round up the chauffeur and the inspector who is in charge of the route. In this way a check can be kept on all trucks plowing.

In order that the trucks may remain on their routes continually, gasoline and oil are supplied to them by a 500-gal. tank truck, which patrols the different districts during the storm.

Motor traffic plays an important part in snow removal. The congestion of motor traffic increases the hazard of plowing, as well as retards the efficiency of the work. Parked motor cars and vehicles prevent the proper removal of snow and add to the difficulties in this important service. These are, however, contingent perplexities which must be met by all municipalities.

Fighting the Storm.—The manner of fighting the storm depends on what part of the day it comes. If the storm comes after midnight, the first district to be given attention is the market section, as this section must be plowed before 6 a. m., the traffic becoming so heavy after that hour that plowing is not satisfactory.

If the storm comes after 6 p. m. we can work on our regular system, but if the storm comes between 7 a. m. and 5 p. m., plowing in the business and railroad sections is a difficult task. We have found that a battery of motor brooms can be worked to good advantage in the shopping district during business hours.

Fig. 5—Identification Tag

When the storm has ceased and the streets are plowed to the satisfaction of the supervisor, the inspector then organizes a snow removal gang by hiring about 20 emergency laborers to load the trucks which he has used in plowing his district to remove the snow to the dumps. In making up the gang it is imperative that the inspector receive the names and addresses of all emergency men, who are then given an identification tag (Fig. 5). This the man must show to the paymaster before signing the payroll.

If, in the opinion of the commissioner of public works, the storm is too heavy to be handled by department forces, another unit is brought in, known as the contractors' removal force, which is in charge of the division engineer of the paving service. The city is divided into 15 snow removal districts. Snow is removed in these districts by contract, the contractor being paid by the yard. Bids are called for in these districts early in November.

Committee on Traffic Relief Named by Secretary Lamont

The committee for the relief of traffic congestion, which will continue the work of the National Conference on Street and Highway Safety, was announced on Sept. 19 by Secretary of Commerce Lamont. E. J. Mehren of Chicago, vice-president of the McGraw-Hill Publishing Company, was named chairman. The other members of the committee named are:

NOMAN DAMON, National Automobile Chamber of Commerce, Washington.
OWEN B. AUGSPURGER, President New York Automobile Club, New York City.
FRED W. BAER, President International Association of Fire Fighters, Washington.
HARLAND BARTHOLOMEW, consulting engineer, St. Louis, Mo.
A. L. BELLE ISLE, President Black and White Cab Company, Atlanta.
R. H. BOYKIN, superintendent of terminals, Erie Railroad Company, Jersey City.
HAROLD S. BUTTENHEIM, editor of the American City, New York City.
R. KEITH COMPTON, Director of Public Works, Richmond, Vt.
G. W. DANIELS, New York City.
LEWIS A. DEBLOIS, Director Safety Engineering Division, National Bureau of Casualty and Surety Underwriters, New York City.
F. H. DEVERE, Auburn, R. I.
LEO J. EASTMAN, President Packard Motor Car Company of New York, New York City.
D. C. FENNER, Mack-International Motor Truck Corporation, New Fork City.
H. B. FLOWERS, President New Orleans Public Service Company, Inc.
J. GALVIN, President Pennoyer Merchants Transfer Company, Chicago.
GOOD STANLEY, Traffic Captain, Police Department, El Paso, Tex.
HAROLD M. GOULD, Consulting Traffic Engineer, Police Department, Detroit.
W. H. HARLAND, Direct of Traffic, Washington.
ARTHUR M. HILL, Vice-President Interurban Automobile Association, Charleston, W. Va.
PAUL G. HOFFMAN, Vice-President Studebaker Corporation, South Bend, Ind.
REYBURN HOFFMAN, traffic engineer St. Louis.
ALFRED KOCH, President of the La Salle & Koch Company, Toledo, O.
V. EVERETT MACY, New York City.
THOMAS S. MacDONALD, Chief of United States Bureau of Public Roads, Washington.
BURTON W. MARSH, Department of Public Safety, Pittsburgh.
MILLER McCLINTOCK, Harvard University.
J. GORDAN McKAY, Highway Research Bureau, Cleveland.
E. J. McILREATH, Chicago Surface Lines, Chicago.
WILLIAM M. NEVIN, Nevin Bus Lines, New York City.
G. H. PRIDE, President of Pride Transportation Company, Brooklyn.
EARL J. REEDER, National Safety Council, Chicago.
HENRY REIMERS, National Furniture Warehouse Men's Association, Chicago.
H. B. POTTER, Vice-President and General Manager of the United Railways & Electric Company, Baltimore.
J. W. ROBERTS, Assistant Vice-President Pennsylvania Railroad, New York City.
WILLIAM P. RUTLEDGE, Commissioner Police Department, Detroit.
FREDERICK L. SWEETLAND, Cleveland.
CHARLES H. TOMPKINS, President Charles H. Tompkins Company, Washington.
COLONEL WILLIAM J. WILGUS, New York City.

The committee, which will hold its first meeting in Washington on Oct. 10, will study the most advantageous methods for meeting the many different problems of traffic congestion.

Information will be developed and made available with respect to the improvement programs now under way in many American cities and applicable alike to the small community and the metropolitan centers.

Two other committees, whose work is in the same general direction, were recently named by Secretary Lamont. They are the committees on maintenance of the motor vehicle and protection of railway grade crossings and major highway intersections.

New Mexico to Adopt Standard Directional Signs

Lining up again with the movement to standardize all road markers as prescribed by the American Association of State Highway Officials, New Mexico will start in a short time to sign her roads with informational and directional signs of the standard adopted by the association.

It was at first planned to erect wooden directional signs on all New Mexico roads from a standpoint of economy. Further inquiry into the subject, however, showed the New Mexican highway officials that such little economy as would be effected by this move was more than offset by the virtues of having New Mexico signs standard with those of other states.

The new signs will supplant all existing ones, particularly those put out by various private enterprises whose main object is advertising a certain product with little regard to the veracity of direction placed upon the sign. Towns, ruins, Indian pueblos, geologic points of interest and freaks of nature will all be signed by the New Mexico department.